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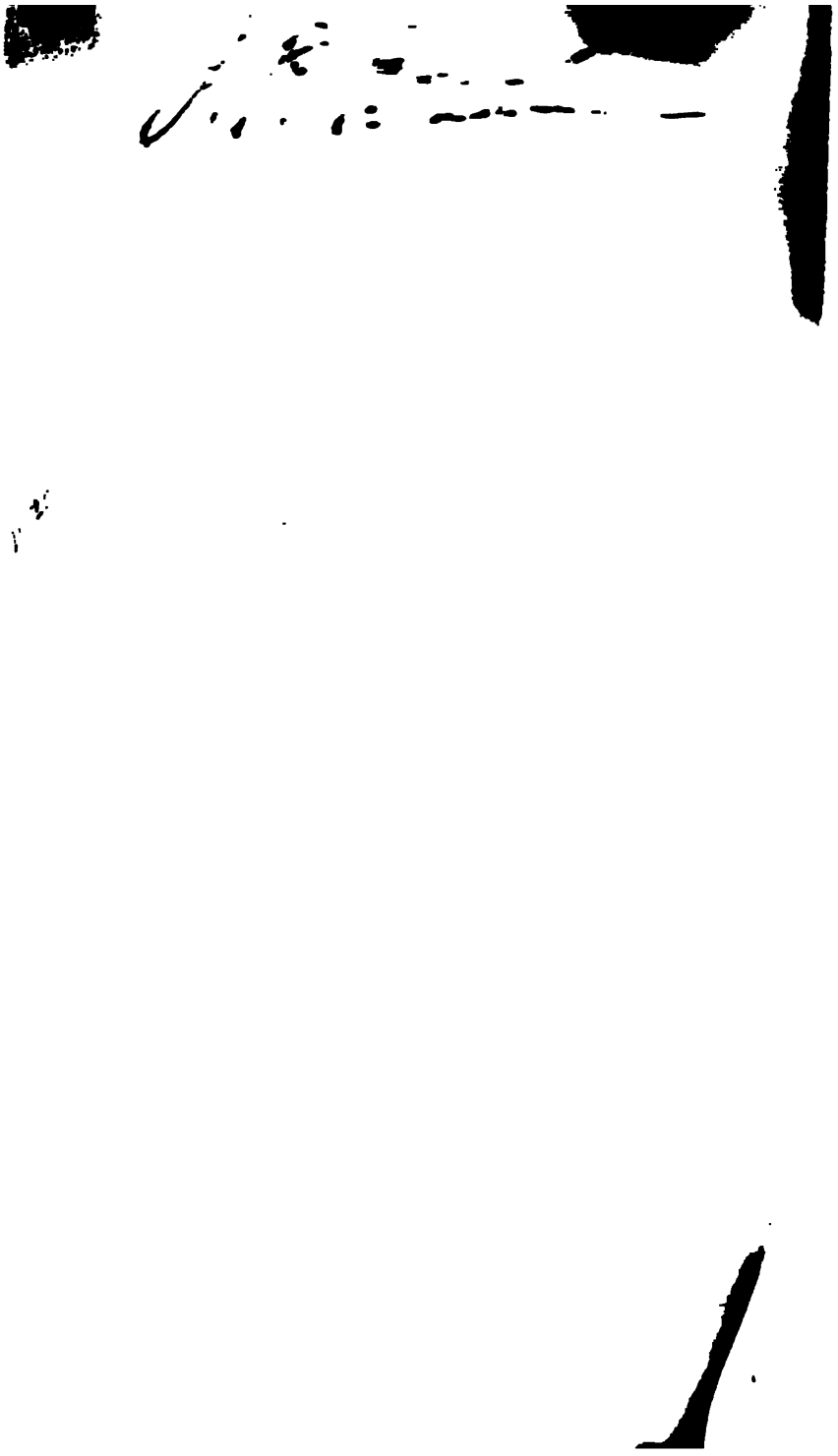

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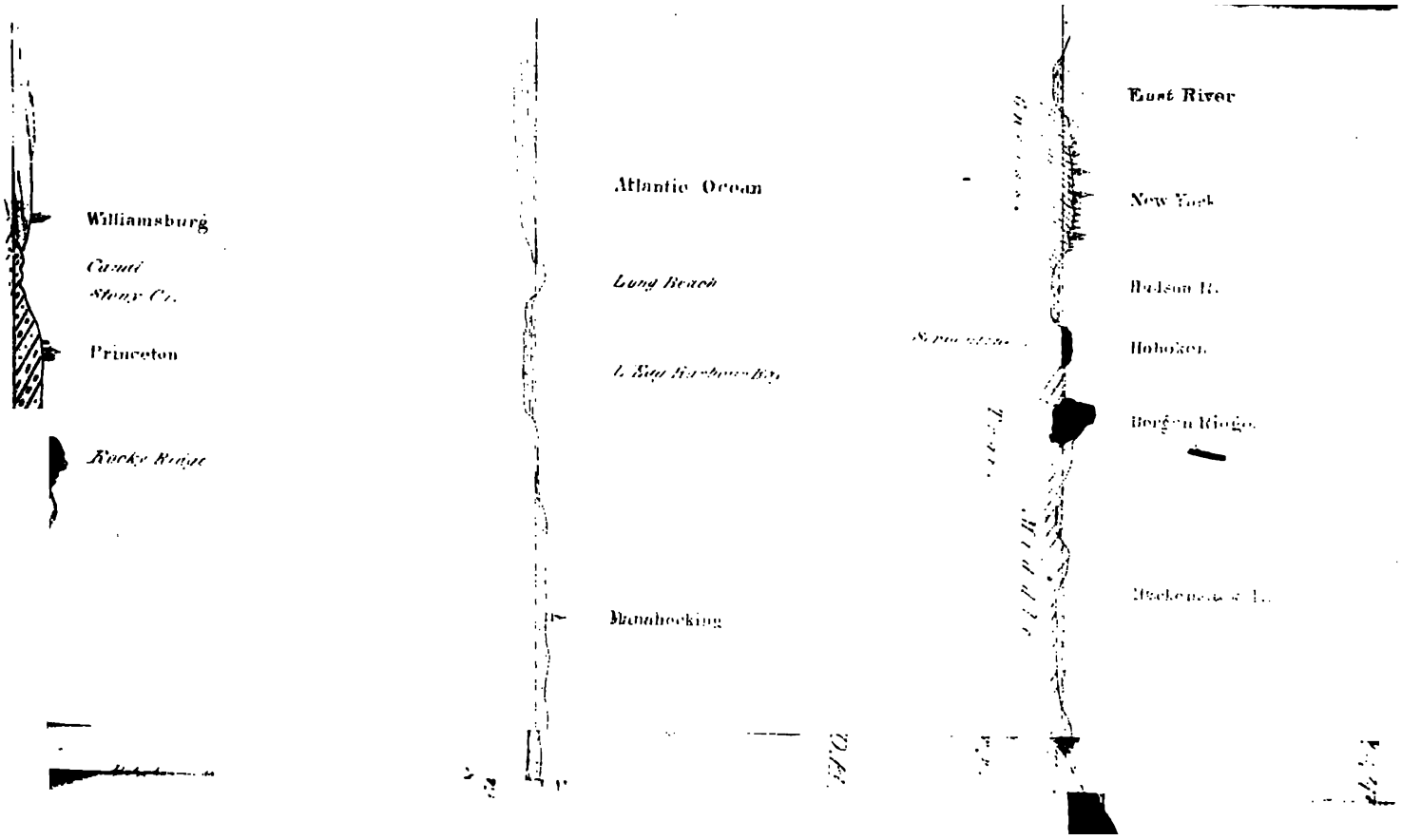
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DESCRIPTION

OF THE

GEOLOGY

OF THE

STATE OF NEW JERSEY,

BEING

A FINAL REPORT,

BY

HENRY D. ROGERS,

STATE GEOLOGIST,

PROFESSOR OF GEOLOGY AND MINERALOGY IN THE UNIVERSITY OF PENNSYLVANIA;
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STANFORD LAW

western side, however, there prevails a tolerably broad belt of much more fertile land, extending from the northern half of Monmouth county, where it is widest, regularly diminishing in breadth, in a southwest direction, to Salem. Its northwestern margin ranges parallel with the Delaware river and the railroad from Bordentown to South Amboy, keeping generally within from three to six miles of them. This highly favoured tract, which is denominated the "Marl Region," and which will be minutely described in the following pages, resembles the rest of the district very closely as to its general topographical features; but offers a striking contrast in point of agricultural productiveness. Its soil, which usually possesses a more or less proportion of the subjacent "marl" or green sand in its composition—deriving hence its superiority—belongs principally to the two varieties denominated by farmers sandy loam and loamy sand.

The northern half of the State, or all that portion of it which lies north of the line connecting the Delaware and Raritan, at points respectively a little below Trenton and New Brunswick, exhibits to the eye of the traveller a scenery wholly different from that of the more monotonous tracts of the southern division just described—possessing a surface at once diversified and picturesque. When we view the several districts included within this interesting and varied region, whether in reference to their distinctive physical features, their particular mineral productions and geological structure, or their characteristic soils, we find the whole susceptible of a natural subdivision into three well-marked tracts.

The *first* of these, or that upon the southeast, comprises nearly one half of the whole area of the northern half of the State, which it crosses in a northeast and southwest direction, from the Delaware river to the New York state line, having a length of about seventy miles. Its southeastern limit is formed in part by the line already mentioned as extending from Trenton to New Brunswick, in part by Staten Island Sound, connecting the Raritan and New York bays, and in part by the Hudson river.

Its northwestern edge coincides with the base of the range of hills denominated in New York and in this State, the Highlands. This boundary follows the foot of the chain from the New York state line in a southwest direction to the Delaware river, coin-

A slightly undulating line, stretching from the Delaware river a little below Trenton to the Raritan river at the mouth of Lawrence's Brook below New Brunswick, divides the State into two regions, which are nearly equal as respects their area, but which are strongly contrasted if we regard their external physical features and scenery, their geological structure, mineral productions, and prevailing soils.

The portion of the State lying south of the Raritan bay and east of the tidewater portion of the Delaware* and the line above mentioned, is remarkable for its low, level, and uniform surface. With the exception of a few isolated hills of humble elevation, which occur at distant points, chiefly in the northern part of the region, this extended plain seldom rises higher than about sixty feet above the sea. It is extensively penetrated, however, by streams that have a very gentle descent from the summit level of the region—one half of them running east and directly into the Atlantic ocean, while the other half pursue a westward course and empty either into the Delaware river or the Raritan. The whole surface of this area is extensively undulated by a system of ravines of denudation, which furnish their drainage to the numerous streams alluded to. These, in connexion with the banks of the streams themselves, afford a ready access, to a moderate depth, to the valuable mineral deposits which expand widely beneath the surface over large tracts of this section of the State.

Throughout this entire district the strata are very nearly horizontal, excepting a brown sandstone and a thin limestone, both of which occur only in a few localities of limited range; the mineral deposits are generally soft and uncemented masses, consisting of a series of alternating sands and clays. From the evidence derived from the organic remains imbedded in the strata of the southern half of the State, these belong, with very few exceptions, to the latest period of the *secondary formations* of our continent. The exceptions referred to are a few very local and shallow deposits of a still later *tertiary date.*

The soil, throughout by far the largest part of this region, is excessively sandy, and more than three-fourths of the surface is covered by an almost continuous forest. Towards its north-

* The tide extends as high up as Trenton.

western side, however, there prevails a tolerably broad belt of much more fertile land, extending from the northern half of Monmouth county, where it is widest, regularly diminishing in breadth, in a southwest direction, to Salem. Its northwestern margin ranges parallel with the Delaware river and the railroad from Bordentown to South Amboy, keeping generally within from three to six miles of them. This highly favoured tract, which is denominated the "Marl Region," and which will be minutely described in the following pages, resembles the rest of the district very closely as to its general topographical features; but offers a striking contrast in point of agricultural productiveness. Its soil, which usually possesses a more or less proportion of the subjacent "marl" or green sand in its composition—deriving hence its superiority—belongs principally to the two varieties denominated by farmers sandy loam and loamy sand.

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Its northwestern edge coincides with the base of the range of hills denominated in New York and in this State, the Highlands. This boundary follows the foot of the chain from the New York state line in a southwest direction to the Delaware river, coin-

ciding for several miles very nearly with the course of the Ramapo river; then pursuing, in a gently curving course, the base of the Pompton Mountain, the Trowbridge Mountain, Mine Mountain, and the Musconetcong Mountain, until it meets the Delaware in the vicinity of Durham.

The average width of the district between the two limits here traced is about twenty miles. Both as respects its geology and its topographical features, this is one of the best characterized belts of country in the State. Most of its surface is a moderately undulating plain, composed almost exclusively of a more or less *argillaceous red sandstone*. But this plain is diversified by numerous abrupt and rugged hills, and long and narrow ridges of no great elevation, but of very steep and rocky sides, consisting of *greenstone trap*, which impart to the district much pleasing scenery, and lend to its geology and mineralogy some highly curious and interesting peculiarities.

The *second* division of this part of the State includes the entire chain of the Highlands, bounded on the southeast by the line already traced along the base of the Ramapo, Pompton, Trowbridge, and Mine Mountains, Fox Hill east of German Valley, and Musconetcong Mountain, and on the northwest by the northwestern base of the ridges known as the Pochuck Mountain, Pimple Hill, Furnace Mountain, Jenny Jump Mountain, Scott's Mountain, and Marble Mountain at the Delaware.

The belt of hills embraced within the limits here delineated is widest towards New York, their breadth at the state line being about twenty-three miles; while a transverse section through Scott's and Musconetcong Mountains near the Delaware will not exceed nine miles.

Though possessing only a moderate elevation, which rarely exceeds six hundred feet, measured from the adjacent valleys, they are distinguished by their mountainous aspect, their sides being usually very rugged and steep, their outlines boldly undulating, and their surface for the most part clothed with forest. The whole group consists of a series of parallel ridges, composed, with the exception of a single range—the Green Pond Mountain—of thickly bedded stratified *primary rocks;* the prevailing direction, both of the strata and the ridges which they form, being about northeast by north and southwest by south. Included between these ridges occur several long, narrow, and parallel

valleys, in which the soil, differing from that of the hills, is fertile and often highly cultivated. The subjacent rocks of these valleys is a blue limestone of the ancient secondary date.

The perfect levelness of certain tracts forms a singular and striking feature in some of these valleys, and in the parts of the red sandstone region bordering the southeastern base of the Highlands. These "plains" are in some instances extensive *natural meadows*, which are in many cases underlaid by beds of *peat*. Among them are the Pompton, Succasunny and Morris Plains. The substratum of these plains is commonly a deep deposit of *diluvial gravel*.

The *third* and remaining district, into which the northern half of the State naturally divides itself, comprising a large part of the counties of Sussex and Warren, is embraced between the northwestern base of the Highlands, already traced, and the Delaware river. A broad and fertile valley, occupying rather more than three-fourths of this district, and bounded on the southeast by the base of the Highlands, and on the northwest by the foot of the Blue and Kittatinny Mountains, extends throughout its whole length, from the New York state line southwestward to the Delaware river.

The average width of this comparatively level belt of country, the proper name of which is the *Kittatinny Valley*, is between nine and ten miles, while its length, from the New York line to the Delaware, is about forty miles. It is drained throughout two-thirds of its entire length by the Paulinskill, which flows nearly centrally along it to the Delaware. The other portion next New York is watered by the Wallkill and its sources. Its surface is moderately uneven, presenting the aspect of a gently rolling plain, intersected here and there by abrupt ravines and the valleys of the streams. It presents many knolls and low ridges, which become more numerous and elevated as we approach the base of the Blue Mountain.

Two varieties of rock, *limestone and slate*, ranging in several parallel belts, some of them throughout its entire length, compose the strata of this valley. The widest zones of the limestone occur in the southeastern half of the valley, while along the northwestern side a broad belt of the slate extends parallel with the base of the Blue Mountain. It has many tracts of highly fertile soil, especially where the limestone underlies the surface.

Bordering this valley on the northwest we have the conspicuous mountain ridge known as the Blue Mountain or Kittatinny, remarkable for the level outline of its summit, the singular straightness of its course, and its superior elevation, compared with any of the other hills of the State. The width of the mountain at its base is from one to three miles, varying at different portions of its length, but being greatest where it traverses the northern half of Sussex county. Its greatest height appears to be at the Water Gap of the Delaware river, where it has been estimated at *Fourteen Hundred and Fifty Feet.*

The materials composing this mountain are hard sandstone and conglomerate, imparting to its steep and broken sides, and to the country immediately at its base, a rough and stony soil, little congenial to the wants of agriculture. Along its northwestern base and slope this high ridge is almost every where covered with forest; but in some portions of its length, especially that part which lies in Sussex county near the New York line, large tracts of fertile farms occupy its southeastern flank. This feature, so unusual to the Kittatinny Mountain throughout its course across Pennsylvania or New Jersey, and which seems confined to this part of Sussex and to the adjacent counties of New York, arises from the circumstance that the soft and tillable slates of the southeastern base of the mountain rise to a more than usual height upon its side in these cultivated sections.

The rest of the northern region of the State lying between the northwestern base of the Blue Mountain and the Delaware river, is comprised in a narrow valley, the surface of which slopes gently to the northwest or towards the river. The soil of this confined belt of country is various, partaking partly of the nature of the several underlying strata, partly of the materials which have been swept hither by floods, from the adjoining Blue Mountain and from the more elevated lands of Pennsylvania, lying to the north and northwest. Immediately bordering upon the river we find a belt of highly fertile land, of diluvial and alluvial origin, gazing upon which the traveller on the summit of the Blue Mountain may regale his eye with a series of highly pleasing pictures, embracing a long tract of the richest farms, the meanderings of the beautiful Delaware, and the picturesque and varied slopes of the neighbouring ridges.

PART I.

GEOLOGY OF THE NORTHERN DIVISION OF THE STATE, EMBRACING THE COUNTIES OF SUSSEX, WARREN, HUNTERDON, MORRIS, BERGEN, PASSAIC, ESSEX, SOMERSET, MERCER, AND PART OF MIDDLESEX.

Of the Formations embraced within the Northern Division of the State.

The rocks which constitute the somewhat diversified geology of the northern half of the State are to be classed in three separate groups, readily distinguishable by their different mineralogical characters, the dates of their formation, and the belts of country to which they severally belong.

Enumerating them in the order of the period of their production, they are,

First. A group of *primary rocks*, confined to the Highlands and the vicinity of Trenton.

Secondly. A group of *older secondary strata*, confined to the northwestern portions of Sussex and Warren counties, from the base of the Highlands to the Delaware river, and to most of the regular valleys between the primary ridges of the Highlands.

Thirdly. A group of *middle secondary strata*, lying in the broad belt of country between the southeastern foot of the Highlands and the boundary connecting Trenton and New Brunswick, including, also, the red shale, red sandstone, and conglomerate rocks, of the Green Pond Mountain. With the above third group are connected the *trap rocks*, which are confined almost exclusively to the region of the middle secondary formation, just referred to. We arrive at a knowledge of the relative dates of these several formations, from the order in which they severally overlap each other: thus, the lower members of the older secondary or Appalachian series, especially the blue limestone, the second from the

bottom of the group, will be found to encircle very extensively the bottom of the hills, or spurs of the Highlands, and to repose at a moderate inclination *unconformably* upon the *primary* rocks of which these hills are composed. In like manner, both along the southeastern foot of the Highlands and around the Green Pond Mountain, the rocks of the middle secondary group are seen to overlie these *lower secondary* or Appalachian rocks with an unconformable inclination, which plainly establishes the subsequence of their date, by showing that the others had already been uplifted before these overlapping rocks were deposited upon them. We behold the trap rocks resting in many instances in their turn upon the middle secondary strata of their district, and with such obvious appearances at the line of contact of the two formations of a disruption and partial fusion of the latter, as to leave no doubt in the mind of the observer, that the former were poured out through fissures in the middle secondary rocks, at a period when these had been already deposited, and at least partially solidified.

The following tabular arrangement of the rocks and strata of the northern division of the State, specifies the name and nature of the several formations, and exhibits the order of their succession from the trap, which is the newest rock of the region, to the primary strata, which are the oldest.

The *Geological Map* will render intelligible the range and extent of each of these formations, while the accompanying *Sections* will point out the manner in which they are severally related in the order of superposition.

TABLE,

Showing the order of succession of the rocks forming the northern division of New Jersey.

Trap Rocks.—Generally coarsely crystalline; sometimes fine-grained and basaltic; they rest unconformably upon the middle secondary strata, through which they have been protruded.

Middle Secondary Rocks.

1. Variegated calcareous conglomerate. Generally a very heterogeneous rock, in which a large proportion of the

pebbles are limestone, the cement consisting chiefly of red argillaceous earth.

2. Red argillaceous sandstones and red shales. Towards the lower part of the formation, contains numerous beds of coarse gray arenaceous sandstone.

Lower Secondary Rocks.

1. A light blue and gray fossiliferous limestone—the lower member of formation VIII. of the Appalachian series—extends between Carpenter's Point and Wallpack Bend.
2. Red and variously coloured argillaceous shales. Passes into a heavy compact red sandstone. Occupies the northwestern base of the Blue Mountain.
3. A compact, white and gray sandstone alternating with massive layers of white quartzose conglomerate—the principal rock of the Blue Mountain.
4. A dark argillaceous shivery slate, sometimes including beds of roofing slate. Kittatinny Valley.
5. Blue limestone—presenting great diversity of aspect and composition—southeast side of the Kittatinny Valley and its branches.
6. A white quartzose sandstone, somewhat coarse and friable. Occurs only in a few isolated localities.

Primary Rocks. These are, almost exclusively, of the stratified class; consisting of *gneiss* under all its forms—the *granitoid* variety greatly predominating. Innumerable small veins of felspathic granite, sienite, &c. penetrate the gneiss.

In offering a systematic description of the geological phenomena of a region, we have our choice either to begin with the deposits of a recent date, referable to easily explained causes, passing successively to those of more remote eras and obscurer origin, or to commence our history with the earlier occurrences of our globe, and trace them in their natural order of succession.

As the latter method seems the one best adapted to our present object, which is not merely to describe the characteristic geological features of the region, but to unfold, in correct chronological order, the successive stages through which it has passed in acquiring its present complicated structure, I shall adopt it in these pages.

The formations will therefore be treated in the ascending order, as regards their superposition, or in the order of geological time, as respects the date of their production.

I shall commence with an account of the geology of the Highlands—these ridges consisting of the oldest or primary formations.

CHAPTER I.

Primary Rocks of the State.—Geology of the Highlands.

Composition and Structure.—The rocks which constitute the chain of hills to which we give the general name of the Highlands of New Jersey, are embraced, with a few exceptions, in the group denominated by geologists the *Gneiss System.* They are composed of the same assemblage of materials as the ordinary varieties of granite, viz. quartz, felspar, mica, and hornblende (and sometimes augite, magnetic oxide of iron, garnets, &c.), but differ from the true granites by possessing a *stratified* structure.

Their strata are, however, very frequently penetrated by veins and dykes of granite, sienite, greenstone, and other rocks of unequivocal igneous origin, a circumstance naturally calculated to lead the inattentive observer to infer that the granitic or unstratified primary rocks form an extensive portion of these hills. This prevailing misconception is heightened by the granitoid character of the gneiss, which is seldom comparatively of the schistose kind, being far more commonly a massive rock in thick beds, containing relatively few divisional planes. Its analogy to common granite is still further increased by the relative deficiency of its mica—the usual mixture being either felspar and quartz, with a little mica, or felspar and quartz alone; or felspar and quartz and an excess of hornblende; and, not unfrequently, felspar, quartz, hornblende and *magnetic oxide of iron*, which in many places seems to take the place of the mica, giving to the rock the speckled aspect of a micaceous gneiss. Magnetic oxide of iron is in fact an abundant, we might almost say a *characteristic constituent* in the rocks of this region, for it occurs not merely as

an occasional ingredient in the gneiss, but in great dykes or veins penetrating the strata. It may be stated as a general feature in the geology of this region, that mica, talc, chlorite and other laminated minerals of the micaceous order—prominent ingredients in the more schistose primary strata—rarely prevail to any extent as regular constituents of the gneiss rocks of the Highlands. In this respect this whole primary chain, viewing it from the Delaware to the Hudson, presents a striking contrast to the other zone of primary stratified rocks, which traverses the country nearer to the seaboard with little interruption from New England to the Southern States. The gneiss rocks of that belt bordering Long Island Sound, passing through New York and Staten Island, reappearing at Trenton, and ranging through Pennsylvania and Maryland, are distinguished for the prevalence of mica and other thinly laminated minerals, imparting to them either the schistose structure or the more or less thinly-bedded character of ordinary gneiss.

A common feature in the massive gneiss of the Highlands is, a tendency to parallelism in the arrangement of its minerals, especially of the felspar and hornblende. In this case the crystals are of a flattish form, and are apt to lie in thin and somewhat separate alternate layers in the rock. This structure seems strictly in harmony with the doctrine which assumes that the so-called primary stratified rocks have been once sedimentary deposits, like the secondary strata, modified into their present crystalline texture by a heat approaching to a partial fusion of the materials. The relative absence of mica and of the more thinly laminated or schistose character, so predominant in some portions of our southeastern primary belt, has arisen, if this hypothesis, usually denominated the "metamorphic theory," be correct, simply from a relative deficiency in the original deposits of those earthy matters, such as clay, lime, magnesia, &c., which are the ingredients of mica and the minerals most nearly allied to it; or, what is the same thing, from a relative excess of silica and those other earths or oxides which are constituents of quartz, felspar, and hornblende. The influence of a difference of temperature in bringing about a difference in the mineral aggregation of the various earths, promiscuously mingled at the period of their deposition, is also possibly connected with the marked contrasts which we see

prevailing in respect to their composition, between the stratified primary or metamorphic rocks of different belts of country.

Notwithstanding the innumerable granitic and other veins, which occur with all the phenomena of violent injection, penetrating at small intervals every considerable tract of the gneiss rocks of the Highlands, these strata are decidedly less contorted and folded together into those minor flexures so usual among the micaceous beds of this rock forming the southeastern belt. This probably arises from the massive character of its strata, and the absence of the more flexible mineral, the mica.

The strata are usually highly inclined, their average dip exceeding 45°. In many of the principal mountain ridges an anticlinal arrangement of the dip is plainly visible. In these instances the strata on one flank of the mountain, the northwestern, are inclined to the northwest, while on the other they dip to the southeast.

The common or rather the almost universal direction or strike of the strata, is from the northeast by north to the southwest by south. They are only occasionally found to depart from this direction, which is that of the principal mountain ridges themselves, and indeed of the entire chain of the Highlands, from the Hudson to the Delaware.

Geographical Extent of the Primary Rocks.—The general limits of the primary region of the Highlands have already been pointed out in the introductory chapter, when describing the physical aspect of the northern division of the State. The southeastern boundary of this belt was there traced as ranging along the base of the Ramapo, Pompton, Trowbridge, and Mine Mountains; thence along the base of Fox Hill east of German Valley, and the foot of Musconetcong Mountain to the Delaware: the northwestern limit was likewise stated to follow the foot of the Pochuck Mountain, Pimple Hill, Furnace Mountain, Jenny Jump Mountain, Scott's Mountain, and Marble Mountain, at the Delaware. Between these two somewhat undulating lines are comprised all the primary rocks of New Jersey, if we except the small triangular tract of gneiss which enters the State at Trenton, and which terminates in a point on the Assympink, about six miles east of that town.

It has been already mentioned, that all the rocks included between

the two margins of the extensive belt above traced, do not belong to the primary class, but that most of the included valleys consist of an ancient secondary limestone, while the Green Pond Mountain is composed, throughout its whole length, of yet more recent formations of the middle secondary date.

To convey a more accurate conception of the areas occupied by the several parallel but somewhat detached belts of primary strata, which together constitute this broad chain of Highlands, we would call attention, in the first place, to the manner in which this whole range of hills is subdivided by several long, narrow longitudinal valleys.

It will be seen by inspecting the Geological Map, that these divide the whole chain into two continuous parallel mountain belts, traversing nearly the entire breadth of the State, and form also several minor interrupted ridges, skirting the former on the northwest and southeast.

Delineating severally the limits of these primary ridges, we begin on the southeast at Mine Mountain. This first tract of the gneiss rocks includes the whole of the elevated ground which commences at Morristown with the name of the Morris Mountain, and terminates under the name of Mine Mountain, in the fork of the north branch of Raritan river and Pepack Brook.

These primary strata, bounded on the northwest by the limestone and other secondary rocks of Mendham Valley, have their margin coincident very nearly with the course of the turnpike from Morristown to the village of Mendham. Thence they are traceable to the south, following the course of the north branch of the Raritan as far as its junction with Mine Brook: from this point they range to the northeastward, parallel with Mine Brook itself, as far as Vealtown, from which their margin is a somewhat undulating line, by Mount Kemble back to Morristown. Except where the short belt of limestone of the Mendham Valley comes in contact with the gneiss, its border, as here traced, is every where overlaid by the red shale and sandstone strata of the middle secondary formation. The general structure of the ridge, as respects the dip and direction of the strata, is such as strongly to imply the presence of an anticlinal axis traversing it longitudinally from northeast to southwest, to which, in all probability, its rocks

owe their elevation. The next continuous zone of primary strata, is one of far more extensive area. It is included between the general northwest boundary of the middle secondary rocks, on the one hand, and on the other, the long unbroken valley, which commences at Clinton, and extends thence along the south branch of the Raritan to its source at Drakeville, and by Green Pond, Macapin Pond, and Long Pond to Dutch Hollow, in the State of New York. Between these limits its range is uninterrupted from near Clinton to the State line, or indeed to the Hudson. To trace this belt of gneiss rocks more exactly, we follow them from the point where the Ramapo river crosses the State line, along the northwestern border of the Ramapo Valley to Pompton, a little north of Ryerson's. Throughout this distance they are overlaid by the middle secondary, red shale, and sandstone group. In the neighbourhood of Ryerson's, a calcareous conglomerate, which when present is the uppermost stratum of that group, lies nearest to the gneiss; the immediate boundary of which, however, is very commonly concealed along the base of the hills, by a deep covering of diluvial gravel. From Pompton, in contact for a part of the space with the diluvial matter which composes the substratum of the Pompton Plains, the gneiss rocks take their course along the foot of the Pompton Mountain by Montville and Boonton Falls, and thence along the base of the Trowbridge Mountain to near Mendham.

As far as this latter point, the overlapping rocks are the upper beds of the middle secondary formation. In the Mendham Valley, the gneiss comes in contact, for a distance of a few miles, as far as Pepack, with the blue limestone of the Appalachian or lower secondary series. From Pepack the formation extends still to the southwest, passing about a mile to the north of New Germantown, and thence in a more westward direction to a point nearly north from Lebanon and two miles northeast of Clinton, where it meets the limestone of the valley of the South Branch. Between Pepack and a point nearly north from Lebanon, the gneiss is, with some few interruptions, in contact with the calcareous conglomerate, the uppermost stratum of the middle secondary rocks. Sweeping round to the north, and afterwards to the northeast, the margin of the gneiss thence pursues the southeastern side of the valley of the South Branch, or German Valley, in contact

with the older secondary limestone, as far as a point about two miles south of Flanders. From hence, along the same side of the same topographical valley, it is marked by the overlapping diluvial matter of the Succasunny Plains. Beyond the termination of these plains, northeast of the village of Succasunny, the primary rocks, pursuing still the southeastern edge of the same valley prolonged, come in contact with the middle secondary strata of the Green Pond and Copperas Mountain, as far as the Pequannock. Northeast of this stream, for a range of several miles, they disappear beneath the older secondary limestone of the Macapin Pond. Beyond this limestone to the State line, they come again in contact with the red sandstone beds of the Copperas Mountain, here called the Long Pond Mountain. This part of the boundary is marked by the southeastern side of the valley of Belcher's creek, nearly to Long Pond.

Another axis or elevated belt of the primary rocks, still more extensive than that just described, as respects length, lies immediately to its northwest, separated only by the long line of valley already traced. The southeastern margin of this latter tract of the gneiss coincides from the State line to the Pequannock, in some places with the red sandstone strata of the Long Pond Mountain, and in some places with the slate and limestone formations of the older secondary group, while in other neighbourhoods, it is separated from these by a narrow strip of diluvium, forming the bed of the intervening valley. From the Pequannock southward to Flanders, it ranges at an average distance of half a mile from the northwestern base of the Green Pond Mountain, its immediate boundary being the diluvium of the Longwood and Berkshire Valley and their prolongation.

Thus covered, the edge of the gneiss passes Drakeville and Flanders, until, beyond the latter place, it encounters the older secondary limestone of German Valley. It thence extends down along the northwestern side of this valley to its outlet north of Clinton, the limestone every where forming the overlapping stratum. From the neighbourhood of Clinton, its course is first nearly westward to the vicinity of Vansickle's, and thence southwestward, following the base of the Musconetcong Mountain to the Delaware. Between the South Branch, north of Clinton and the head of Milford creek, the gneiss rocks dip beneath the ancient lime-

stone; but from the latter point to where they strike the Delaware, they are overlaid, throughout the chief part of their course, by the calcareous conglomerate, which caps the middle secondary series.

The northwestern margin of this same chain of the gneiss, is marked by the edge of the Musconetcong Valley, and sometimes by the border of that stream itself, along the entire distance between its outlet at the Delaware and the head of the valley, near the old Andover Forge, the primary strata every where descending beneath the older secondary limestone. From the old Andover Forge, it follows nearly the brink of Musconetcong creek by Stanhope to Brookland, at the outlet of the Hopatcong Pond, being generally, except at Stanhope, in contact with the limestone. It there folds round the base of a hill west of the Pond, which it pursues, passing a little east of Columbia Forge and the villages of Sparta, Ogdensburg, Hamburg, and Vernon, to New Milford, at the State line. In all this part of its somewhat undulating course, the gneiss dips beneath the overlapping edge of the older secondary limestone.

The mountain belt of which the boundary has here been traced, consists essentially of a single uninterrupted belt of axes of elevation, giving to it a general anticlinal structure. It receives, nevertheless, several distinct appellations, applied to different portions of it. Between the sources of the Pequannock and the deep transverse gorge which almost intersects the chain at Drakesville, it takes the title of the Hamburg or Wallkill Mountain. From the cross valley above mentioned to that of Spruce Run, it bears the name of Schooley's Mountain, while between the latter limit and the Delaware river, it is called the Musconetcong Mountain.

To the northwest of the great continuous belt of primary hills, whose boundaries have just been traced, there rises a chain of rather less elevated scattered ridges, which occupy insulated tracts in what, if we take a comprehensive view of the topography of the region, ought to be regarded as the southeastern portion of the Kittatinny Valley. These hills are surrounded on all sides by the older secondary limestone of that valley, through which at least some of them seem to have been protruded subsequently to the period of deposition of the limestone over the gneiss. Though they do not constitute a strictly connected range

of the formation, they evidently compose, like the chain to the southeast, one general belt of axes of elevation, inasmuch as they all lie within a narrow zone and nearly in the prolongation of each other. The limestone which encircles them, usually dips *from* their flanks, apparently in consequence of an upheaving action near a central line traversing each hill longitudinally.

Proceeding with our detailed delineation of the boundaries of these primary tracts, we first meet, towards the northeast, the Pochuck Mountain. This ridge, in which the gneiss has evidently an anticlinal arrangement, though a somewhat irregular one, commences in New York, about a mile northeast of the State line, and terminates near the village of Hamburg, having a length of about eight miles, and a breadth ranging between one and two miles.

At its southeastern base, the primary rocks disappear beneath the limestone of the Hamburg, or Black Creek Valley; while along the northwestern side they are overlapped by the same formation, a little east of the Meadows of the Wallkill. This ridge is interesting from its having, towards its southwest termination, a valuable deposit of *brown hematitic iron ore*, to be hereafter described.

The next ridge of importance is Pimple Hill, which, together with a spur which it throws off towards Sparta, extends from near that place to Franklin. On the southeast flank of this ridge of primary, is the much celebrated Sterling Mine, consisting of zinc ore and Franklinite.

From Sparta there extends, towards the southwest, another elongated narrow belt of the primary to within a mile and a half of Andover village, while, about a mile to the northwest of this belt, which is bounded by the limestone of a highly crystalline and altered aspect, there lies a small oval hill of the gneiss, also similarly encompassed. Next, in our progress to the southwest, we encounter two other low and detached hills of the primary, both of them lying a little east of the turnpike which joins Stanhope and Andover. Immediately west of this road, we meet with a larger tract of the primary, which extends continuously almost to the road which unites the villages of Hacketstown and Vienna. Its southeastern boundary passes Lockwood and the old Andover Forge, thence along the western side of the Hacketstown Valley

to near the road last mentioned, its northwestern margin passing by Alamuche.

From the vicinity of Hacketstown to near Mount Bethel Meeting-house, there ranges another low ridge of the gneiss, having a length of about four miles and an average breadth of one. Resting upon the primary strata of this tract, is a small patch of nearly white sandstone, well adapted for purposes of architecture, for which it has been occasionally used. This is one of a few isolated patches of the lowermost rock of the older secondary or Appalachian series, in New Jersey; a formation displayed so extensively in contact with the primary rocks of the same general chain, both in New York and Pennsylvania. Another locality of the sandstone is to be found between Flanders and Succasunny, northeast of the former village; and two other exposures, are visible near Macapin Pond, where the rock is in contact with the overlying blue limestone.

Another considerable surface of the gneiss extends from near the village of Mansfield southwestward to the Easton turnpike, a little west of Bloomsburg; bounded on the northwest by the Pohatcong stream, and on the southwest by the valley of the Musconetcong.

The next important belt of primary rocks is that of the mountain called Jenny Jump. This ridge, extending from near the outlet of Bear Brook at the Great Meadows, almost to the village of Sarepta, is about seven and a half miles long, by about one in mean breadth.

Its rocks are every where overlapped around its base by the ancient secondary limestone; an interesting zone of which, in a highly crystalline and altered condition, ranges along its southeastern foot for nearly its whole length.

Two small patches of the primary rocks, which seem to have been exposed by denudation of the limestone, occur in the valley of the Pequest, between that stream and the foot of Jenny Jump.

South of the Pequest rises the conspicuous ridge of primary rocks, called Scott's Mountain. Its length is about twelve miles, while its general breadth somewhat exceeds three. Encompassed at its base by the limestone, the southeastern limit of the gneiss ranges parallel for several miles with the Pohatcong stream, and afterwards with the Morris canal; while, on the

north, the valley of the Pequest is the boundary as far as Bridgeville. On the northwest, the margin is pretty nearly marked by the road uniting this place and Oxford. It extends thence through the spot called Concord to Harmony Church.

The last belt of the primary strata to be traced is that of Marble Mountain, at the Delaware: this is also surrounded by the limestone, but its western base is almost washed by the Delaware river. It terminates towards the southwest near Phillipsburg, opposite Easton; and towards the northeast almost unites with Scott's Mountain, near Harmony Meeting-house. Its length is about four miles, and its average breadth one mile.

Of the Igneous Rocks and Metalliferous Veins of the Highlands.—The metalliferous veins of the primary region of the State, though extremely numerous and widely distributed, embrace but few varieties. As regards their general structure, they are all, in fact, very nearly alike; while the only ores they comprehend in large amount belong to the two metals, iron and zinc; those of iron being by far the most abundant.

Structure of the Veins.—In their form they are unequivocally genuine lodes or veins, and often of considerable longitudinal extent coinciding with occasional slight deviations, with the direction of the strata which include them. Their position is usually between walls of the granitoid gneiss, to which they are parallel, not only in strike, but in dip. They exhibit, however, many minor irregularities, such as frequent changes in thickness, suddenly bulging to great width, and rapidly thinning out to almost imperceptible dimensions. This observation is to be received as applying with fullest force to the whole body of injected matter, regarding it as one vein, which it truly is; while the distribution of the ore within the vein is liable to even greater irregularities. Viewing these veins comprehensively, they consist not exclusively of the metalliferous ore, whatever it may be, but of the ore and other minerals, particularly hornblende and felspar, in one general injected mass. In some instances, the ore constitutes the body of the vein, resting in contact with the gneiss rock of the walls; in others, it occupies only a part of the thickness of the mass, being bounded on either one or both of its sides by the non-metalliferous minerals, usually termed the gangue; while in other cases again, the vein of ore is split by a wedge of the

same gangue, which either entirely cuts it off on one side, or being of limited length, soon permits the reunion of the divided portions.

Not unfrequently this gangue comprises the chief width of the vein, and the ore included in it lies in detached elongated bodies of lenticular form, having their longer axes always in the direction of the course of the vein. These insulated masses of the ore, denominated *pots* or *pools* by the miners, are sometimes more than a hundred feet in length, their thickness varying in certain large veins from five to forty feet.

Another feature, deranging occasionally the uniformity of these veins, presents itself, when detached portions or splinters, as we may regard them, from the adjoining strata constituting the walls, are found lodged in the substance of the lode. These and other smaller wedge-shaped masses, interrupting or dividing the vein, are commonly entitled *horses* by the miners.

In addition to these irregularities in the distribution of the ore, we sometimes find the entire vein cut through by faults crossing it, commonly almost at right angles, and totally interrupting its continuity.

The several circumstances here spoken of in the structure of these metalliferous veins, seem strongly to imply that they are real veins of injection, and not true beds, contemporaneous with the adjoining gneiss, as some have supposed. A common thickness of the metalliferous veins under description is from six to twelve feet; in their inclination or pitch they are quite various, some dipping, with the strata that enclose them, at as low an angle as 50°, while many are nearly vertical. In the shallower excavations the workings are open to the sky, and the deepest shaft yet sunk, that of the Mount Pleasant Mine, near Dover, in Morris county, is only about two hundred and twelve feet below the surface.

Nature of the Ore.—The ore belongs to the species denominated by mineralogists *oxidulated iron* or *magnetic iron ore*, and is of two varieties—compact and granular. In its purest form, this mineral consists of two atomic proportions of the *peroxide* of iron, and one of the *protoxide*, which is equivalent to nearly 72 per cent. of the former, and a little more than 28 per cent. of the latter—yielding about 72 per cent. of metallic iron. In the

state in which it is more usually met with, however, mingled with a greater or less proportion of extraneous mineral matter, the amount of metallic iron contained ranges between 60 and 72 per cent. It is magnetic, being endowed with the property of attracting soft iron, and affecting the magnet. Masses of it are frequently met with possessing a distinct magnetic polarity, the opposite ends manifesting a repulsive action upon the corresponding ends of the needle. Such specimens are termed loadstones.

Though the pure variety is often massive, and mingled with but little foreign mineral matter, yet this is really less productive in the manufacture of iron than the granular or imperfectly crystalline kind, in which we find a moderate proportion of small crystals of hornblende, felspar, quartz, and other minerals, interspersed with the ore. Some of the ore contains a small proportion of titanium. The veins often exhibit a tendency to cleave by numerous natural joints, extending across from one wall towards the other; a structure which suggests a strong analogy to the horizontal columnar arrangement seen in many vertical dykes of lava and basalt. This, if the proofs already cited were not enough, deserves to be regarded as an argument in behalf of the opinion that these veins of ore have been injected, while in a fused or molten state, into the gneiss, and are not in the strict sense *beds* formed contemporaneously with the surrounding rock.

This point, though at first sight unimportant, and seemingly one of mere theory, is of much practical moment to the miner, since it acquaints him with the nature of the veins in which he is operating.

Local Details.—In offering a detailed description of the veins of magnetic iron ore as far as they have been developed, we shall begin, for the sake of convenience, with those lying towards the northeast. The first which claim our attention are those of Pompton township, in Bergen county. The principal veins of this tract occur in the continuation of the Sterling Mountain of New York. In the ridges immediately west of the Ringwood Valley at least two extensive veins are known.

The most southeastern of these has been explored for much the greatest distance, several mining excavations having been made

in it, throughout a length of nearly three miles. That to the northwest is distant from the former about two hundred feet, and, where it has been traced or mined, has been found to preserve a parallel direction with it. The first mentioned of these veins extends to within a quarter of a mile of the New York line. Their course is north northeast and south southwest. The rock of this region, containing these veins, is the ordinary granitoid gneiss, abounding in hornblende, and nearly destitute of mica. It has a steep dip to the southeast.

Following the most southeastern of these two veins, from the southwest to the northeast, the first considerable excavation which displays its structure is an old mine, quarried open to the day, to the depth of perhaps forty feet, and for about three hundred and fifty feet along the vein. The pitch of the vein at this point is nearly vertical. Its general regularity is somewhat disturbed by trivial slides and sudden changes of dip. Large wedge-shaped masses of the gneiss rock of the walls intrude themselves into the middle of the ore, subdividing the veins into two or more branches, which send off parallel filaments, that either dwindle out entirely in the rock, or reunite with the main body of the vein.

The mean thickness of the ore in this mine is about ten or twelve feet, exclusive of these interposed masses of rock. Though not at present used, the ore is stated to be of average purity.

About one hundred feet to the northeast of this is the mine known as the *Blue Mine*, from the bluish hue of the ore. The excavation from which the ore has been removed, is about one hundred feet in length by fifty feet in depth, while the width of the vein varies from six to fifteen feet.

At this place also the vein is divided in the middle of the ore by a vertical wedge of rock, which increases from one to five feet in thickness, and consists on the one side of red felspar, like the adjacent wall of the vein, and on the other of compact green *sahlite*. In this part of the vein are several oblique dislocations or slides, always declining to the southeast.

Within less than half a mile to the northeast of this last opening there is another point where excavations have been made, called the *Mule Mine*. The principal vein of ore here is seven or eight feet thick, swelling out at some spots to twenty feet.

Formerly it was extensively wrought, open to the sky, to a depth of seventy feet, and length of one hundred yards. Within only a few paces to the southeast of this opening, which is called the Blue Hole, is another in a more circumscribed vein, of a lenticular form, called the *Mule Ore*. This shorter vein is divided through its middle by a wedge or horse, consisting principally of massive crystallized hornblende.

Exclusive of this intruded mass, the vein, at its widest place, where it is at present worked, is twenty-five feet in thickness. At a somewhat greater distance, on the opposite or northwest side of the principal vein, occur three or more similar detached small veins, or, as we ought, perhaps, more properly to say, lenticular portions of the general vein. One of these pots or pools of ore, denominated the Henion Mine, is about fifty feet in length by ten feet in thickness. It has been wrought to a considerable extent, yielding an ore of excellent quality.

The ore of this and some of the other small subordinate veins possesses the magnetic character in a distinguishing degree.

The whole of the ore of this immediate vicinity of the Mule Mine is stated to make a good iron, which is apt, however, to be *red short*, or brittle, at a red heat.

The pitch of the principal vein of ore of the Mule Mine is parallel to the dip of the adjoining gneiss rock, which is to the southeast at an angle of about 60°.

Northwest of these several workings of the Mule Mine, and higher up the hill, we meet with another set of short, lenticular outbursts of the ore, wrought by the name of the Cannon Mine.

The greatest width of the ore in the main excavation here is forty feet, caused, however, by the coalescing at this point of two adjoining masses, which are elsewhere separated by wedges or horses of the gneiss rock. The largest of these divisions of the vein is fifteen feet across. Another somewhat oval mass, lying almost in the prolongation of the one here mentioned, and only separated from it by an intervening wall of gneiss a few feet thick, has furnished at its widest part a nearly solid body of ore, thirty feet in thickness.

These ores smelt with facility, but produce a highly brittle, or *cold short*, iron.

Beyond these excavations, to the northeast, succeeds the

Peter's Mine, formerly worked, partly in a shaft, partly in a quarry open to the sky.

At this place the dip, both of the vein and the primary strata bounding it, is at an angle of about 60° to the southeast. The rock above the ore is a mixture of felspar and mica in a state of disintegration; in other places it consists of a fine pinkish felspar rock in the same rotten condition. The form of the vein at the place where it has been worked, is that of a narrow wall of ore, six feet in thickness, which presently swells into a huge mass of an oval form, fifty feet in diameter. This pool of ore has been wrought beneath the open air to a depth of about seventy feet, the water being drained off by an adit cut through the adjoining wall of gneiss.

This ore is said to yield an iron which is brittle at a red heat, or red short.

The Spanish Hope and Good Hope mines form the next group of openings as we proceed to the northeast. They occupy the southwestern extremity of a spur of the main mountain, and occur at a distance of not more than one-third of a mile from the New York state line.

The hill in which these mines lie is very rugged, and the ordinary gneiss rock composing it much disturbed, connected with a considerable degree of irregularity in the metalliferous veins. The general width of the main body of ore is about eight feet, dipping with the strata to the southeast at an average inclination of 70°. The most northwestern of these openings, called the Good Hope Mine, exhibits the vein in considerable regularity, dipping at an angle of about 80° to the southeast, and having a pretty uniform width of nearly twelve feet. These mines were somewhat extensively worked by an English company before the revolutionary war: the Good Hope Mine now showing a large excavation, sixty feet in depth. The ore proved of superior quality, which led, about twenty years ago, to a resumption of mining operations, which have been since abandoned.

In the same prolongation, towards the north-northeast, we find a continuation of this series of mines for several miles into the State of New York, but whether these occur upon the same line of veins, seems to be not quite established.

Reviewing in their general connexion the whole line of veins

of iron ore here described, we are forcibly impressed with the belief, that while they are of a moderate length, taken individually, they are to be regarded as constituting but one long and extensive belt of closely connected metalliferous injections, contemporaneously produced.

It appears from what has been detailed, that the ore in its course to the north grows more uniform and undisturbed. The general quality of the ore along much of the line here traced is excellent, answering well for the bloomery or the furnace. Much of it is coarsely granular, which is a good feature; a portion, however, is too compact—being somewhat refractory and red short—especially a particular band or subdivision of the vein.

Near the openings first mentioned, the second or northwestern vein has been penetrated throughout a length of about one hundred feet, and to a depth not exceeding thirty. Its ore makes an iron highly cold short, a circumstance which has caused the vein to be less explored than the other, though it is probable that it ranges over a considerable distance. Its position is parallel to the first. The dip is to the southeast, and its width about ten feet. The ore in these veins is highly magnetic, some of it possessing magnetic polarity. It is a coincidence which deserves at least to be alluded to, that in another even richer locality of magnetic iron ore, namely, that of Mount Pleasant and Succasunny, in Morris county, there exist two extensive veins or series of veins, the predominant character of the western vein in that neighbourhood being just as at Ringwood, that of producing a cold short iron.

About midway between Ringwood and Pompton, or six miles from each place, a vein occurs in a similar position to the above, on the west side of the Ringwood Valley, having exactly the same bearing, namely, north-northeast.

Westward of the iron range here laid down, there would appear to occur between this and the vein of Franklinite and zinc of the valley beyond the Wallkill Mountain, more than one considerable and valuable vein of magnetic ore. We may mention the veins of Charlottesburg and those of the Wallkill Mountain, four miles east of Franklin Furnace, as examples.

The next district in the primary region, remarkable for an abundance of magnetic iron ore, is a range of country extending

between the Pequannock and Succasunny, running from the northeast to the southwest, parallel with the Copperas Mountain, at a distance from it of between two and three miles. The rock of this region is the usual granitoid gneiss, consisting principally of felspar and hornblende. The strike of the strata here, as almost every where else, is to the south-southwest, the usual direction of the dip being towards the south-southeast, and at high angles, commonly exceeding 60°.

A series of parallel veins, or more properly speaking, of parallel belts of closely contiguous veins, consisting of very excellent magnetic iron ore, imparts especial interest to this range.

I shall allude more particularly to three of these belts of ore, conspicuous for their length and well-developed features. Though the excavations yet made are not sufficiently numerous to establish satisfactorily either the independence or the strict continuity of the several portions of a vein or veins occupying the same line of bearing, yet the indications are, that the individual veins are of considerable length, say several furlongs, but by no means prolonged over the whole district.

I incline to view each supposed long vein as made up in fact of a string of several veins very nearly in a line, one commencing either at or a little before the termination of another.

As the question of their strict continuity is one of little practical importance, we may venture, for the sake of present convenience, to designate them as three great veins, inasmuch as they lie in three separate parallel zones. From a little to the northeast of Hibernia, where the larger exposures of the ore commence, to a point at some distance southwest of Succasunny, where they at present cease, the space over which these belts of the magnetic ore have been worked, is upwards of ten miles.

The inclination and strike of the several veins coincide, whenever they are at all regular, with that of the enclosing strata of gneiss. Their direction is from north-northeast to south-southwest.

Commencing with the southeasternmost line of ore at present developed, we find upon it the two mines, entitled Muir's Mine, and Sweed's Mine. The next parallel belt towards the northwest embraces the Hibernia Mine, Jackson's Mine, and Dickerson's Mine, near Succasunny. The third range includes the Denmark

Mine, where no large vein of pure ore has yet been discovered; the Mount Hope Blue Mine, Mount Hope Mine, Teabo Mine, Mount Pleasant Mine, Harvey's Mine, Sterling Mine, and Burwell Mine. These several mines are here designated in the order in which they occur, passing from northeast to southwest. It is not intended to convey the impression that the above classification into three belts of veins is regarded as positively accurate, for the distances between the excavations, especially along the two first ranges, are so very considerable, as to suggest a reasonable doubt whether we might not refer them to a greater number of parallel belts.

Describing the mines in the order above given, we find the most northeastern of the southeastern range, to be the excavation called Muir's Mine. This is about a mile and a half to the northwest of Rockaway. The vein at the surface of the ground, where it is occasionally exposed, is six inches thick, widening as it descends, and becoming two and a half feet thick at the depth of thirty feet. The adjoining rock is a compact gneiss, dipping parallel with the vein, which inclines at an angle of 45° or 50° to the southeast.

At a considerable distance to the southwest of the above is Sweed's Mine, situated about midway between Rockaway and Dover. Here the general features are the same, the dip being 50° to the southeast.

The thickness of the vein of solid ore varies from five to twelve feet. Next to the hanging or overlying wall, there is usually a band, of about three feet in thickness, of excellent compact ore; beneath this succeeds four feet of spar, consisting largely of vitreous felspar, and under this again occurs a very poor ore, mingled largely with the extraneous mineral matter of the foot-wall or floor, from which the vein is not clearly separable. The separation between the vein and the hanging wall, on the contrary, is well defined. The upper division of the vein is soft and of a granular structure, and yields a good iron. The impurer portion next the foot-wall affords, on the contrary, an iron characterized as *red short*. It is worthy of remark, that the adventitious matter in the red short ore, is not different from that in the ore of standard goodness. The ore in the vein is thrown into some irregularity by wedges or horses of a species of rock,

composed apparently of the injected gangue of the ore, consisting of hornblende or blackjack and mica, with a variable proportion of ore in an irregular crystalline or granular form. The mine is drained by an adit which passes out through the side of the hill next the east.

Upon the second or middle range of mines, the most north-eastern excavation is the *Hibernia Mine.* The situation of this mine, which is upon the top of an elevated hill, adjacent to the Hibernia Forge, renders it somewhat difficult of access. The ore here also sometimes shows itself upon the surface, though it more frequently requires an excavation of moderate depth before it can be reached.

The dimensions of the vein are quite variable, though its average thickness is perhaps about eight or nine feet. The ore, containing much foreign mineral matter, and being at the same time highly magnetic, affords an opportunity for using the magnetic separating machine, by which it is economically freed from its impurities.

About half a mile to the west of Dover is Jackson's Mine, yielding an ore similar to the last. This is inferred, by its position, to lie upon the same vein or string of veins.

The vein is here seven feet in width. There is a shaft leading down to the ore forty feet deep. The excavation is about two hundred feet in length.

The next, and by far the largest vein of the range, is half a mile further towards the southwest, at General Dickerson's, near Succasunny. Here the enclosing rock is a variety of gneiss, composed chiefly of quartz and felspar, with occasionally a little mica and oxidulated or magnetic iron ore, disseminated through it. The dip is about 60° to the southeast. The mine has been wrought to a depth of about eighty feet. In the horizontal drift, along which the vein has been chiefly worked, the quantity removed has been very great. Here the average thickness may be stated at about twelve feet, though near the entrance of the mine, in consequence of an irregularity, the mass of ore seems to have been at least thirty feet across. This being in a disturbed portion of the vein, the presumption is, that it does not continue far of this dimension.

The general structure of this ore is highly granular, showing a

frequent approach to the octohedron, the regular crystalline form of this species of iron ore. It is also sometimes of the compact variety. It is considered equal to any in the State for the quality of the iron which it produces. The same vein is said to have been opened still further to the southwest, but the remotest point in that direction to which it may be traced has not been ascertained.

Three varieties of the ore occur at the Succasunny Mine—a blue ore, a reddish ore, and a sparry ore. The first lies next to the foot-wall, the red ore occurring adjacent to the hanging wall, while the sparry ore runs generally in separate veins between the rest of the vein and the hanging wall. One vein of this variety, measuring twenty-two inches in thickness, is divided from the other part of the ore by only about three or four inches of rocky matter.

The price of the *blue* and *red* ores at the mine is $3.50 per ton; that of the sparry ore, somewhat less rich in iron, is $2.50. The mine is not very actively worked; about fifteen hundred tons per annum having been mined during the last five years.

Entering in the next place upon the third or northwestern belt of veins, we commence, towards the northeast, with the unimportant excavations near the old Denmark Forge, which are to be regarded as openings in search of ore rather than a regular mine. The first mine of consequence in this series is the *Mount Hope Blue Mine*, now no longer wrought, occurring at a distance of nearly four miles to the southwest of the Denmark openings. The vein seems to average from twelve to fourteen feet in thickness. At the surface of the ground the vein was from eighteen to twenty feet thick. It has been worked to a depth of one hundred feet, being, at the deeper portions, as much as twenty-four feet in thickness.

The excavations consist of a series of inclined galleries, at a slope of about 25°, in descending zigzag arrangement. The ore has been removed throughout a length of several hundred feet. The mine has been abandoned in consequence of the too rapid accumulation of water. An adit, carried into the mine from near the base of the hill, would seem to be all that is required to give access once more to this large mass of ore.

The next mine, in our progress to the southwest, is the

Mount Hope Mine, about a quarter of a mile from the former, and upon the same line of metalliferous injections. Its position is upon the northeastern brow of a hill, about three hundred feet in elevation, overlooking the old *Mount Hope Furnace*. The quality of the ore appears to be analogous to that of the Mount Hope Blue Mine. The thickness of the vein varies, being only one foot at the south end of the mine, and six feet at the north end. A shaft has been sunk here between seventy and eighty feet in depth. This mine is now in operation.

About one-fourth of a mile to the southwest of the last occurs the *Teabo Mine*, on the southwestern declivity of the same hill. Here the vein of ore is almost ten feet in thickness, holding a nearly vertical position, its inclination being towards the southeast. The walls are regular and unbroken, consisting of a rather micaceous gneiss. This is one of the veins in which the *horizontal columnar structure* of the ore is very obviously displayed. A wedge of rock separates the vein in one or two places, but only for a short distance. The ore is of excellent quality, though compact, the foreign matter mingled with the magnetic oxide of iron consisting of a green hornblende and some quartz. The mine is about one hundred feet in depth, the length of the excavation exceeding one hundred and fifty feet.

Upon the same supposed northwestern vein or belt of ore, and one mile further to the southwest, is the Mount Pleasant Mine. The average thickness of the vein may be given at about eight feet, though it is very variable, changing from eighteen inches to twelve feet, and sometimes thinning away, for a short space, almost to nothing. These fluctuations of width take place as well in the vertical as in the horizontal direction. The rock immediately adjacent to the ore, from all appearance protruded contemporaneously with it, is an almost pure hornblende, having an extremely beautiful massive crystallization. The material of the regular wall, on the one side, is a hard, light-coloured felspathic rock, while that of the other, or hanging wall, is chloritic and often micaceous. In driving to the southwest in one of the galleries of this mine, the progress of the vein was suddenly arrested by a cross dike of quartz rock, fourteen feet in thickness. After many fruitless borings for the recovery of the vein, it was discovered, heaved to the southeast, many feet

out of its original line. Beyond the dike the vein is tossed about in very considerable confusion, the masses of ore occurring rather in detached pools than in one continuous lode.

The dip of the regular portion of the vein is to the southeast. The depth to which the mine has been wrought is two hundred and twelve feet. Lying below the surrounding streams, its drainage is effected by machinery; a series of well-contrived pumps, driven by a small brook acting on a water-wheel, being employed for the purpose.

Nearly a mile and a half west of Dover we find the *Harvey Mine*, once extensively wrought by a shaft, but now no longer in operation. The ore here resembles that of the Mount Hope Mine, lying in a vein which varies from four to nine feet in thickness.

About three-fourths of a mile west of Dover occurs the Sterling Mine, not at present wrought. The vein of ore was found to vary from two to thirteen feet in thickness. At one spot, at twenty feet from the surface, it was only eighteen inches wide, but grew larger lower down. The walls consist of a hard dark-coloured granitoid gneiss. Several shafts were sunk upon this vein; the deepest, however, did not exceed thirty-five feet.

The last in this series of mines lies about half a mile southwestward from the Sterling Mine, and is known as the *Burwell Mine*. The vein of ore is about eight feet wide. Two shafts have been sunk upon it.

Not far from Mount Pleasant, there is a small mine upon a vein which is supposed to lie to the southeast of those above traced. But little is known of the length or course of this vein, any further than that its direction and dip are parallel with those of the others.

A similar vein is known, and has been mined to a considerable extent, near Powerville; and no doubt many more exist in the district, though nothing has been done to develope them, and no useful facts concerning them have come to light. It should be mentioned that the long range of ore veins above traced, lies almost exactly in the bearing of the vein near the old Charlottesburg Furnace, on the Pequannock.

But few indications of iron ore have been hitherto discovered in the southwestern prolongation of this first or southeastern

chain of the Highlands, in that part of it which is called the Chester Mountain.

Adverting in the next place to the metalliferous veins of the other great parallel range of primary hills, which includes in one continuous chain the Wallkill, Schooley's, and Musconetcong Mountains, we are forcibly struck with the fact of their relative fewness, when compared with the numerous and extensive injections which traverse the more southeastern belt, above described.

Upon the Walkill or Hamburg Mountain magnetic iron ore may be occasionally met with in the soil, while excavations made at various spots have also brought to light small bodies of the ore, but no veins of considerable magnitude.

Advancing along this chain towards the southwest, we meet with similar indications of ore in the neighbourhood of Stanhope, and also south of this, in the vicinity of Flanders, where many loose fragments of it occur in the soil, especially in the neighbourhood of Bartley's Forge. About three-fourths of a mile north of the forge a small excavation for ore may be seen, which, it is said, yielded a mineral of good quality. An opening has also been made about a mile from Mount Olive, but it did not develope a vein of any magnitude.

Nearly a mile and a half northeast of Drakestown, on Schooley's Mountain, a digging was lately made (summer of 1838), which produced some ten or twelve tons of ore, of a highly magnetic character, pronounced to be of good quality: but it did not lead to the developement of a regular and solid vein.

Upon the same mountain, and about a mile and a half east of Hacketstown, some ore is visible in the soil, but of too quartzose a nature to produce a good iron. The diggings which were made at this spot did not succeed in disclosing a regular vein.

Upon the mountain, a few furlongs to the west and northwest of the Heath House, ore in considerable abundance strews the surface of the fields. A portion of the mineral here is pretty largely contaminated with hornblende, augite, and other foreign substances, which do not, however, materially interfere with the reduction of this species of ore into iron, except where their quantity is considerable. Much of the ore of the same locality, is dis-

tinguished by having the magnetic property, sometimes in a high degree, many masses being found endowed with magnetic polarity in unusual strength.

Numerous small openings have been made here, at various times, in quest of a regular and solid vein, but, until recently, none promising to be of useful quality and dimensions have been explored. From some excavations lately made the indications seem to be more encouraging.

In the Musconetcong Mountain, the appearances of the surface do not justify the hope of there being any considerable veins of the magnetic ore.

The next and last tract of the primary hills, towards the west, abounding in this valuable mineral is Scott's Mountain, in Warren county.

A brief account of the veins in the vicinity of Oxford Furnace, the locality of chief importance in that district, will complete the details which we have to offer upon the subject of the magnetic iron ore of the region.

Here, as elsewhere, the direction of the veins is parallel with the bearing of the strata of granitoid gneiss which include them. There appear to be at least two principal veins, but the precise thickness of either it is difficult to ascertain, owing to their varying constantly in their dimensions. The quantity of ore, however, is enormously great. The veins are divided here and there, by thin beds of the rock, into several parallel branches, so that the aggregate width of the ore has not been wrought in many places. The adjoining strata are, moreover, considerably disordered, and the veins are, in consequence, thrown out of direction by two or three pretty large faults. These are connected with detached or broken off portions of the lodes, two of which are known to sweep round a curve of almost semicircular form.

Some portions of the adjacent strata contain the oxidulated magnetic iron in a crystalline state, disseminated in sensible proportions through the rock, or rather through certain layers, either associated with the hornblende or replacing it.

The greater part of the ore resembles in quality that of the ranges before described, being the magnetic oxide of iron, either compact and massive, or in granular crystallization. It has the

defect common to nearly all the veins in the primary region; that is to say, it is apt to be *too compact* for easy reduction in the furnace. It yields an excellent iron, and seems especially well suited for making castings.

Let me here be permitted to express the hope that this favoured region of New Jersey, so eminently enriched by nature with that most valuable of mineral treasures, iron, is destined to behold, at no very distant day, a brighter era as a manufacturing district. Two important new methods, recently introduced into the smelting of iron, namely, that of the hot blast and the substitution of anthracite coal for charcoal—now become in many districts of the State too scarce to be employed—seem peculiarly well adapted to remove some of the difficulties which attend the use of these compact magnetic ores. These obviously require a more elevated temperature for their profitable reduction than can be given them by the aid of charcoal and the ordinary blast, and seem particularly to call for the application of the modern improvements referred to. The success which has lately attended the use of anthracite in the smelting of iron in Pennsylvania, suggests that New Jersey need no longer be prevented from availing herself of the advantages, arising from her superabundant treasures in ore, by the absence of wood upon her hills.

Conclusions deducible from the previous facts.—The first theoretical inference, naturally suggested by the remarkable manner in which all the veins, without any exception, occur is, that the primary strata existed in all probability at a rather steep inclination before the intrusion of the veins; for it is inconceivable how a forcible injection of fluid ore could enter a series of beds, lying in a nearly horizontal position, without in some cases causing and occupying fissures transverse to the strike of the strata. The fact that other similar veins—those of the altered white limestone of Sussex—occupy a corresponding position in reference to the neighbouring strata, and appear to have been produced after the formation of the limestone, is another argument lending probability to the notion that their origin was subsequent to the formation and upheaving of the gneiss.

Moreover, it is not difficult to conceive, that if the strata were previously nearly vertical, or at a high angle, the molten ore would easily insinuate itself in the plane of the strati-

fication of the rock, this being the direction in which the strata would most readily give way. If the rule be a general one, that these veins range and dip parallel to the strata, we are led to some important general hints for seeking and opening mines in this region. One is, that the veins of ore may be expected to follow the same layer or bed of rock for a considerable distance; and that the nature, therefore, of the *adjoining rock*, will often prove a clue for finding a previously known vein in the direction towards which it is prolonged. Another suggestion is, that when levels are cut, or shafts sunk to reach a vein, the indications of which are witnessed upon the surface, the excavations should be made on that side of the presumed *outcrop* of the vein which is towards the *underlie*, or dip of the gneiss, because the vein, keeping parallel with the rock, will descend in that direction.

Respecting the geological date of these veins of magnetic iron ore, it seems difficult, from the imperfect nature of the data afforded by the region, to arrive at positive conclusions. The views which we here venture to suggest in the light of the hypothesis on the subject, are offered as merely conjectural. They are deemed at the same time worthy of a place in our account of the geology of the Highlands, as assisting to throw light upon other questions hereafter to arise, and as opening a train of inquiry interesting to future investigators—some of whom, let us hope, may hereafter find an inviting field for research in the structure and former physical history of this mountain belt.

In examining the question of the date of the veins of magnetic iron ore, our attention is at once called to the interesting general fact, that these veins lie exclusively in the primary rocks. I think we must conclude, that most, if not all of these veins of ore, were etruded from their deep source beneath the surface, during the epochs which preceded the deposition of the first widely dispersed secondary strata.

CHEMICAL COMPOSITION OF THE MAGNETIC IRON ORES OF THE HIGHLANDS.

Suggestions concerning the treatment of these ores, can be of service to the manufacturer only in proportion as they are the results of numerous and precise chemical investigations into their composition.

composed apparently of the injected gangue of the ore, consisting of hornblende or blackjack and mica, with a variable proportion of ore in an irregular crystalline or granular form. The mine is drained by an adit which passes out through the side of the hill next the east.

Upon the second or middle range of mines, the most north-eastern excavation is the *Hibernia Mine.* The situation of this mine, which is upon the top of an elevated hill, adjacent to the Hibernia Forge, renders it somewhat difficult of access. The ore here also sometimes shows itself upon the surface, though it more frequently requires an excavation of moderate depth before it can be reached.

The dimensions of the vein are quite variable, though its average thickness is perhaps about eight or nine feet. The ore, containing much foreign mineral matter, and being at the same time highly magnetic, affords an opportunity for using the magnetic separating machine, by which it is economically freed from its impurities.

About half a mile to the west of Dover is Jackson's Mine, yielding an ore similar to the last. This is inferred, by its position, to lie upon the same vein or string of veins.

The vein is here seven feet in width. There is a shaft leading down to the ore forty feet deep. The excavation is about two hundred feet in length.

The next, and by far the largest vein of the range, is half a mile further towards the southwest, at General Dickerson's, near Succasunny. Here the enclosing rock is a variety of gneiss, composed chiefly of quartz and felspar, with occasionally a little mica and oxidulated or magnetic iron ore, disseminated through it. The dip is about 60° to the southeast. The mine has been wrought to a depth of about eighty feet. In the horizontal drift, along which the vein has been chiefly worked, the quantity removed has been very great. Here the average thickness may be stated at about twelve feet, though near the entrance of the mine, in consequence of an irregularity, the mass of ore seems to have been at least thirty feet across. This being in a disturbed portion of the vein, the presumption is, that it does not continue far of this dimension.

The general structure of this ore is highly granular, showing a

frequent approach to the octohedron, the regular crystalline form of this species of iron ore. It is also sometimes of the compact variety. It is considered equal to any in the State for the quality of the iron which it produces. The same vein is said to have been opened still further to the southwest, but the remotest point in that direction to which it may be traced has not been ascertained.

Three varieties of the ore occur at the Succasunny Mine—a blue ore, a reddish ore, and a sparry ore. The first lies next to the foot-wall, the red ore occurring adjacent to the hanging wall, while the sparry ore runs generally in separate veins between the rest of the vein and the hanging wall. One vein of this variety, measuring twenty-two inches in thickness, is divided from the other part of the ore by only about three or four inches of rocky matter.

The price of the *blue* and *red* ores at the mine is $3.50 per ton; that of the sparry ore, somewhat less rich in iron, is $2.50. The mine is not very actively worked; about fifteen hundred tons per annum having been mined during the last five years.

Entering in the next place upon the third or northwestern belt of veins, we commence, towards the northeast, with the unimportant excavations near the old Denmark Forge, which are to be regarded as openings in search of ore rather than a regular mine. The first mine of consequence in this series is the *Mount Hope Blue Mine*, now no longer wrought, occurring at a distance of nearly four miles to the southwest of the Denmark openings. The vein seems to average from twelve to fourteen feet in thickness. At the surface of the ground the vein was from eighteen to twenty feet thick. It has been worked to a depth of one hundred feet, being, at the deeper portions, as much as twenty-four feet in thickness.

The excavations consist of a series of inclined galleries, at a slope of about 25°, in descending zigzag arrangement. The ore has been removed throughout a length of several hundred feet. The mine has been abandoned in consequence of the too rapid accumulation of water. An adit, carried into the mine from near the base of the hill, would seem to be all that is required to give access once more to this large mass of ore.

The next mine, in our progress to the southwest, is the

The following analyses will exhibit their average richness in iron; and display, moreover, the amount and nature of the extraneous substances, which occasionally interfere with their reduction.

ANALYSES.

Peters' Mine, Ringwood, Bergen county.

Description.—Ore, magnetic, perfectly granular and crystalline; the grains uncommonly large and distinct. Contains a few spots of yellowish decomposed mineral. It is extremely friable.

Specific gravity.—5·112 at a temperature of 65·5° Fahr.

Composition.—Iron, - - 71·9 per cent.
Insoluble matter, 0·3 do.
Alumina, - a trace.
Lime, - - none.

Good Hope Mine, Ringwood.

Description.—Ore, magnetic, beautifully crystalline; the grains exhibiting nearly regular facets. Contains a little interspersed yellowish clayey matter.

Specific gravity.—5·019 at temperature 50° Fahr.

Composition.—Iron, - - 71·88 per cent.
Insoluble matter, 1·5 do.
Lime and alumina, a trace.

"Cannon Ore," Ringwood.

Description.—Ore, magnetic, highly crystalline; the grains distinctly angular and rather small. Contains much white and greenish mineral matter.

Specific gravity.—4·685 at temperature 69° Fahr.

Composition.—Metallic iron, 63·2 per cent.

Mount Hope Blue Mine, Morris county.

Description.—Ore, magnetic, compact and massive; having but little of the granular structure. Fracture nearly flat, but not smooth; somewhat mottled with white and greenish specks.

Specific gravity.—4·918 at temperature 65° Fahr.

Composition.—Metallic iron, - 69.6 per cent.
Insoluble matter, - 2·8 do.

Teabo Mine, near Dover.

Description.—Ore, magnetic, compact, slightly granular, fracture irregular; lustre, brilliant, metallic. Contains dispersed grains of hornblende and vitreous felspar.

Specific gravity.—44·82 at a temperature of 69° Fahr.

Composition.—Metallic iron, - 64·9 per cent.
Insoluble matter, - 6·2 do.
Lime and alumina, a trace.

Mount Pleasant Mine, near Dover.

Description.—Ore, magnetic, compact and massive; somewhat granular; grains less than the average size; contains greenish and white specks of extraneous matter.

Specific gravity.—4·697 at a temperature of 70° Fahr.

Composition.—Metallic iron, - 65·99 per cent.
Insoluble matter, - 7·2 do.
Lime and alumina, slight traces.

Sterling Mine, near the Mount Pleasant Mine.

Description.—Ore, magnetic, massive and granular; grains distinct, interspersed with specks of a whitish decomposed mineral, amounting to almost one-half the whole bulk.

Specific gravity.—4·691 at a temperature of 66° Fahr.

Composition.—Metallic iron, - 66·4 per cent.
Insoluble matter, - 4·4 do.
Alumina, rather more than a trace.

Succasunny Mine.

Description.—Ore, magnetic, highly crystalline; grains large and distinct.

Composition.—Peroxide of iron, - 70·00 per cent.
Protoxide of iron, - 28·25 do.
Oxide of titanium, - a trace.
Oxide of manganese, - a trace.

Oxford Furnace Ore, Scott's Mountain, Warren county.

Description.—Ore, magnetic, and somewhat granular and fri-

able. Contains numerous grains of felspar, hornblende, and other extraneous minerals.

Composition.—Peroxide of iron,	-	67·25 per cent.
Protoxide of iron,	-	26·50 do.
Oxide of manganese,	-	0·50 do.
Oxide of titanium,	-	a trace.
Silica, - -	-	2·10
Alumina, &c. -	-	3·00

The analyses of these ores being undertaken with a view to ascertain more particularly the quantity of metallic iron, the process adopted was to dissolve the powdered ore in nitro-muriatic acid, precipitate the iron by potash, to redissolve it in excess of acid, and subsequently precipitate it by ammonia.

A portion, considered as representing the average composition of the specimen, was selected for examination. In each instance the specific gravity has been taken by Nicholson's hydrometer.

Five or six times the amount which was employed for analysis being finely pulverized, from ten to twelve grains were generally used, this being found the most convenient quantity for accuracy.

It deserves the attention of those engaged in manufacturing iron from these ores, that very frequently the portion of the vein lying immediately beneath the surface, and the fragments and grains of the ore, which often fill the soil in very considerable abundance, are much softer than the ore in the main body of the vein. The action of atmospheric agents upon it appears to have rendered it more yielding, and it consequently mingles more readily in the furnace with the other materials, greatly facilitating the smelting of the mass. The clay and earthy matters, which remain attached to the surface ore, even after it is washed free from the loose soil, account, in part, for its beneficial effects; for, the highly silicious nature of the foreign minerals in the ore, seem to counteract, in part, the fluxing agency of the limestone, and render it less efficient than when other ores are smelted. Some trials have been made at the Oxford Furnace, which consisted in mixing a loamy clay with the ore, in addition to the limestone, and were decidedly encouraging. The loose surface ore, therefore, merits the attention of the smelter. At Oxford Furnace, the soil con-

taining it is washed in a stream of water, running through troughs; after which it is sifted, and the increase in the product proves that the extra labour spent in preparing it is economically bestowed.

In two or three places, in the iron region, *magnetic separating machines* are used to clear the ore of the foreign mineral matter with which it there is mixed. They are applied, of course, only when the quantity of non-metallic matter is so large as to constitute a motive for removing it; nor are they admissible except where the ore is highly magnetic. One has been used at Ringwood, and another at Hibernia.

It is a curious circumstance, that the igneous injections, penetrating the older secondary limestone of the chain of valleys, north of the main range of the Highlands, from Amity, in New York, to Scott's Mountain, producing a striking change in its structure, though sometimes wholly metalliferous in their nature, rarely embrace veins of magnetic iron ore such as belong to the gneiss of the Highlands.

Some of the veins of magnetic iron ore, penetrating the gneiss, may, therefore, claim an earlier date than those metalliferous and non-metalliferous veins which traverse only the subsequently formed blue limestone.

The highly singular phenomena, connected with the intrusion of these last named veins in the limestone rocks of the valleys, will demand a particular description, which it is deemed proper, however, to defer, until the general geology of the older secondary strata shall have been previously discussed.

Gneiss Formation of Trenton.—The very extensive belt of stratified primary rocks, which ranges nearly parallel with the Atlantic coast, and forms the western limit of the tide in the rivers of Virginia, Maryland, Delaware, and Pennsylvania, after gradually contracting in width, crosses the Delaware at Trenton, and soon entirely vanishes, dwindling to a point about six miles to the northeast of the state metropolis. Its further course through the State is concealed by the overlying horizontal deposits of clay and sand, referable to the greensand series. The formation again comes into view in Staten Island, Long Island, and New York.

Where it crosses the Delaware, this belt of gneiss is about

three and a half miles broad, narrowing in its course to the north-northeast, until, by the overlapping of the newer beds upon it, the visible portion of the formation fines away almost to a point, about the sixth mile-post upon the Delaware and Raritan canal. The triangular area which it forms has the valley of the Assunpink very nearly for its southeastern boundary, while its northwestern margin is formed by the lower members of the overlying middle secondary sandstones. Throughout the whole included space, the mineralogical character of the rock is extremely well marked. It is usually a triple mixture of quartz, felspar, and hornblende, the latter being frequently replaced by mica. Like the rock of the other primary zone of the State, the Highands, it goes very frequently under an improper name, being called a granite, and sometimes a sienite. Its well-marked dip and stratification, its occasionally schistose structure, and the decisive fact of its running in strict continuity with the acknowledged gneiss rock of the Schuylkill above Philadelphia, are sufficient to establish its claim to be considered a portion of the great Atlantic belt of gneiss.

A little north of Trenton, and near its border, there is a quartzose variety of the rock, containing a little mica, giving it the laminated form, but the mass of the rock is a close-grained stratified mixture of felspar and quartz. This band consists of an intimate mixture of quartzose and felspathic matter fused together. It seems to be continuous with the felspathic rock of Barrel Hill, in Montgomery county, Pennsylvania. Splitting into rather well-formed large slates, and having a smooth surface, it furnishes a very good flag stone for the walks and steps in Trenton.

Wherever the stratification of the gneiss can be seen, it is found to dip at a steep angle, nearly 70°, to the southeast. And there can be no doubt that it underlies unconformably both the upper secondary, or greensand deposits on its southeast, and the middle secondary, or argillaceous red sandstone formation, on its northwest. One variety of the rock possesses the general aspect of a sienite, and another often contains such an excess of hornblende as to cause it to resemble closely a greenstone or basalt, for which it might be taken were it not for the stratified structure evident in almost every mass. In some portions the quartz is blue, semi-transparent, and opalescent, and the hornblende and felspar show

a tendency to decomposition. It is met with of this variety upon the canal about two miles from Trenton, and in several places further to the northeast, as far as the spot where the rock ceases to show itself in place, which is about three and a half miles from the town. It may be traced about two miles further, by observing the character of the diluvium above it.

Its economical importance consists chiefly in its including several valuable varieties of building stone, well adapted to structures demanding solidity and strength. Some of it would make a very fine road-stone. To the scientific world it is interesting, as presenting one of our few localities of *zircon*, which occurs about fifty yards above the bridge at Trenton. The soil over this formation is a very heterogeneous mass of diluvium, derived from the gneiss and the formations to the northwest. It is generally gravelly. In the valley of the Assunpink it is often a greenish sand and gravel, derived from the quartz and hornblende, and is then rather sterile.

CHAPTER II.

OF THE OLDER SECONDARY OR APPALACHIAN ROCKS.—GEOLOGY OF THE KITTATINNY VALLEY, WITH ITS BRANCHES, AND OF THE REGION OF THE KITTATINNY MOUNTAIN.

Nature and Composition of the Strata.—Having in the last chapter described the general and local geology of the primary districts of the State in as much detail as the limits of the present work would permit, I propose, in the present place, to offer a similar account of the geological features and structure of the region occupied by that extensive group of formations of exclusively sedimentary origin, which I conceive to have been deposited during the period that next succeeded the first elevation of the primary strata.

As these sedimentary rocks repose in immediate contact with the gneiss, presenting, from the attitude of their beds, abundant evidence that they were precipitated upon it while it was yet only in part elevated above the waters, and, as the same strata,

moreover, hold a similar relation to our primary rocks throughout their entire range, from Vermont to Alabama, separated from them by no other group of strata yet discovered, claiming an earlier origin, I have deemed it expedient, for the sake of classification, to confer upon them the title of the *Older Secondary Strata* of the United States. Constituting almost the entire chain of the Appalachian or Alleghany system of mountains, in which the whole series is not only much more complete but better developed than in an any other region of the continent, I have thought it judicious elsewhere in my geological descriptions to propose for these rocks the synonyme of the *Appalachian System of Strata.**

Comparing them with the older secondary rocks of Europe, they are evidently related, as respects their date, more nearly to the English silurian strata than to any other known system. The probable extent of their *affinity* to these will be touched upon under another more suitable head.

Confining our attention in this place to those members of the older secondary series which enter the territory of the State, they will be found to comprise the *five lowermost* formations of that extensive group, together with the lower division of the *eighth* (the sixth and seventh being absent), counting always in the ascending order.

The *first*, or *lowest* of these, seen only in two or three localities, is a white sandstone, Formation I. of the general Appalachian series; the second in the order of superposition, is the blue limestone of the Kittatinny Valley and its branches, and is Formation II. of that group; the third great stratum is the slate of the same wide valley, and in the general series is Formation III.; the fourth is the rock of the Kittatinny, or Blue Mountain, a gray sandstone, passing into conglomerate, and is designated as Formation IV.; the fifth is the red sandstone, Formation V., occupying the northwestern flank and base of the Kittatinny Mountain; while the *sixth*, and uppermost, is the blue fossiliferous *limestone*, skirting the valley of the Delaware, from Wallpack Bend to Carpenter's Point, being the lower division of Formation VIII. of the same Appalachian system.

* See Annual Reports on the Geological Survey of Pennsylvania.

The following table will serve to explain more clearly the order of stratification, and the prevailing composition of these several rocks.

TABLE,

Of the Lower Secondary or Appalachian Rocks, as they occur in New Jersey.

FORMATIONS IN THE ASCENDING ORDER.	PREVAILING COMPOSITION OF THE STRATUM.	MAXIMUM THICKNESS.
VIII.	A light blue and gray limestone; some of the beds argillaceous; others, more or less magnesian; many layers abounding in fossils. Lies at the bottom of Formation VIII.	Probably 200 feet.
V.	A group of alternating red sandstones, and red, argillaceous shales; the lower layers, a very compact and ponderous sandstone, of a claret red colour. These contain *fossil fucoides.*	About 2000 feet.
IV.	A set of compact white and gray sandstones, with layers of quartzose conglomerate. Contains several species of fucoides.	About 2000 feet at Delaware Water Gap.
III.	A thick mass of dark, argillaceous slates —bluish, black, gray, greenish-gray, or olive, yellowish, and red. Affords good roofing slate; contains, also, beds of dark gray sandstone, and a few layers of conglomerate. Occasionally exhibits marine fossils.	Not positively known, but thought to be at least 3000 feet.
II.	A blue limestone, occasionally magnesian. Contains thin beds of chert.	Not positively known; probably upwards of 2000 feet.
I.	A compact and very quartzose sandstone, of light bluish-gray colour, approaching to white.	Whole thickness not ascertained, owing to denudation.

SECTION I.

Of the White Sandstone—Formation I.

Geographical Extent.—This formation, so largely developed in Pennsylvania, in the flanks and even summits of the hills, which constitute the same chain as the Highlands, I have hitherto discovered in only three or four small isolated tracts in New Jersey. The first locality, commencing towards the northeast, is north of the Pequannock, between Long Pond and Macapin Pond. Its position is in a narrow belt of the ancient secondary rocks, which extends for several miles along the confined valley included between the eastern base of the Green Pond Mountain and the primary hills directly east. The first visible mass of the sandstone occurs about two miles north of the farm of Richard Gould, Esq., or about four miles south of Long Pond. The rock here lies near the base of the primary hills. It probably extends southward in a continued belt for several miles beneath the limestone (Formation II.) of the same valley, though it does not show itself again until we reach the farm of Mr. Gould, where it is displayed near the head of Macapin Pond, in an interesting exposure, at the base of a ridge of the limestone, dipping beneath that rock at an angle of 60°.

The next spot at which this stratum reveals itself at the surface, is, in the prolongation of the same valley, and about midway between Flanders and Succasunny Plains. The rock occupies a small low hill, nearly but not exactly in a line with the low ridges which constitute the denuded extremity of the Copperas Mountain at Succasunny. The stratum has evidently sustained extensive denudation, only a patch, not more than a mile in length, of the lower portions of the formations being left in the middle of the valley. The rock is nearly white, very quartzose, and somewhat friable in texture to a considerable depth below the soil, yielding, therefore, a very pure white sand.

The only remaining locality at present known occurs on the northwestern side of the small ridge of primary strata, which commences a little to the west of Hacketstown, and extends thence southward about four miles. The range of the sandstone,

occupying a confined area upon this ridge, is very limited. The rock is of a grayish white, has an even texture, dresses readily under the hammer of the mason, and is, in many respects, entitled to attention as a material well adapted for architectural uses. It has been occasionally employed with that view at Hacketstown.

Almost every where else along the boundary which separates the limestone from the primary rocks, where this formation should be found, we find either no traces of it whatever, or else here and there a *debris*, consisting of a white sand and gravel, derived from the destruction of the rock at its outcrop. The frequent accumulation of the large deposits of diluvial matter at the bases of so many of the primary hills, together with the easy destructibility of the rock itself, which can nowhere within the State have attained to a great thickness, will serve to explain the very limited extent to which it is exposed.

SECTION II.

Of the Blue Limestone (Formation II.) of the Kittatinny Valley and its Branches.

The second rock of the Appalachian series which we meet with in the ascending order, is the great *blue limestone* formation of the southeastern half of the Kittatinny Valley, and of most of the valleys included between the several ranges of the primary hills, or Highlands.

Geological range of the Formation.—Omitting, for the present, the task of tracing the lesser belts of the blue limestone, which occupy the narrow longitudinal valleys of the primary chain and the valley of the Paulinskill, and restricting our attention to the principal tract of this formation in the State, we may define it in general terms, as occupying the southeastern half of the Kittatinny Valley, understanding this name in its most comprehensive sense as extending to the base of the long *continuous* mountain range, known as the Wallkill, Schooley's, and Musconetcong Mountains. Within this broad belt rise up a number of the detached primary ridges of the general chain of the Highlands, whose exact position and boundaries we have already traced.

The continuity of its surface is still further interrupted near its

northeastern margin, by a succession of long and narrow synclinal belts, consisting of the slate of the overlying formation.

The general southeastern border of this large limestone district has been already traced in sufficient detail, when describing in another chapter, the northwestern limit of the main continuous range of the primary, above referred to. It was stated as keeping a little to the southeast of the Musconetcong creek from its mouth nearly to Stanhope, towards its source, and thence to extend in a more wavering line along the base of the Wallkill Mountain to New York.

Its northwestern margin, separating it from the main continuous slate belt of the Kittatinny Valley, may be given as extending longitudinally in a somewhat undulating course, through the middle of that valley, from a little above Belvidere, on the Delaware, to near the intersection of the Wallkill and the state line of New York.

Tracing this boundary more minutely, it will be found, beginning at the Delaware, to run in a northeast direction for about four miles, to the little village of Sarepta, to deflect thence north for several miles, to the Free Church, on the road from Hope to Columbia; passing which, it sweeps again towards the east, until it reaches the vicinity of Johnsonburg. From this point to the New York line, it preserves a nearly straight course, skirting the town of Newton on the northwest, passing a little west of the village of Harmonyvale and a corresponding distance east of Deckertown, and meeting the meadows of the Wallkill about three miles to the southwest of the line bounding the State.

The large zone of limestone now delineated, offers many curious features to the geologist. Conspicuous among these are its numerous anticlinal axes and the striking phenomena of an induced crystallization, effected along certain belts of the stratum by the heating agency of the numerous igneous dikes and veins which traverse it. These will be systematically described and traced in their own more appropriate places. In the mean while, we proceed to give the boundaries of the other lesser bands of the limestone formation.

Next in extent of surface to the broad area already traced, is the smaller parallel tract of the valley of the Paulinskill, lying to the northwest. Commencing at Coursinville in a wedge-shaped

point, in the midst of the wide tract of the slate of Sussex county, it ranges southwestward, following nearly the valley of the Paulinskill creek to its mouth, and terminating in another wedge-shaped point on Cobus creek, in Pennsylvania, about a mile and a half beyond the Delaware. It has the form of a long, continuous, and nearly straight belt; varying between one and two and a half miles in breadth. The only conspicuous irregularity in its margin, is where a long narrow tongue of the overlying slate intrudes itself into this tract northwest of Newton, following the immediate valley of the Paulinskill for several miles.

The physical features of this extensive range of the limestone, are those of a valley deriving its outlines from an active denudation of the rocks along an axis of elevation which traverses it nearly centrally from one extremity to the other.

On the opposite or southeastern side of the main zone of primary rocks which crosses the State, we meet with the limestone extending at somewhat interrupted intervals in a long narrow band, in the bed of that great continuous valley which separates the main chain of the Highlands longitudinally into two nearly equal wide belts of hills.

Taking up this range of the limestone at its northeastern extremity, the first narrow band which we encounter, is between the outlet of Long Pond, and the outlet of Macapin Pond, along the eastern base of the Long Pond Mountain. This exposure of the rock is about three and a half miles in length, commencing about two and a half miles north of Macapin Pond. Another very small patch of the limestone presents itself about one mile to the northeast of the head of Green Pond. Both this and the former locality, exhibit a considerable quantity of fossil marine shells in the rock, belonging, however, to but a limited number of species. Elsewhere, throughout the State, this limestone formation is singularly deficient in organic remains; and consequently, these isolated tracts derive considerable interest to the geologist from their fossiliferous character.

Extending our researches through the same general valley, we again come upon the limestone, about two miles to the southwest of Flanders, from whence we may trace it in an interrupted belt down German Valley to Clinton, and thence along the south-

eastern base of the Musconetcong Mountain, past Vansickle's to Pattensburg, reappearing again within a few miles of the Delaware, and extending to the river.

The small isolated range of this limestone in Mendham Valley, forms the only remaining tract of the formation in the State. It occupies the bottom of the valley, lying between the base of the Mine Mountain and the Trowbridge Mountain, and first shows itself about a mile east of Mendham, from whence it extends to near the mill, which is a short distance below the village. There it disappears beneath the overlying beds of the middle secondary red sandstone series, which repose unconformably upon it. It soon emerges again from beneath this covering, and may be traced nearly from Ralston's to the Pepack Brook.

Composition and Structure of the Rock.—This rock possesses a remarkable diversity of aspect and composition. It assumes almost every variey of tint, from a deep blue, almost approaching to black, to the lightest shades of gray; but its prevailing colour is a soft grayish blue. It is equally multifarious as to texture, presenting every possible gradation, from an almost crystalline character, to the closest and finest earthy aggregation of the particles. When the latter character is associated with a clear tint of blue, and with a sharp, smooth, well-defined and conchoidal fracture, the rock usually consists of pure *carbonate of lime;* while, on the other hand, a rougher texture, a duller tint, and a more irregular surface of fracture, indicate the presence of other materials.

The extraneous ingredients which most abound, are *carbonate of magnesia, alumina,* and *silica;* while *oxide of iron* and *carbon* also frequently enter into its composition, but in less proportion. The rock is sometimes sandy, especially in the lower part of the formation; and it is frequently in other portions more or less argillaceous, in which case it is apt to present a partially slaty structure. It is also thin-bedded or flaggy, but oftener occurs in layers of from several inches to a foot or more in thickness.

Throughout a large portion of the geographical range of this rock, it exhibits in a greater or less degree, the *oblique cleavage planes,* so conspicuous in many belts of the slate, which adjoins it. As this interesting subject of the cleavage of rocks will be considered more in detail when discussing the geological features of

the slate, it is passed by for the present, with the remark that the general direction of the cleavage planes in the limestone follows strictly that which prevails almost universally in the slate, the dip and strike of these planes of cleavage being in both formations entire, independent of the direction of the dip of the strata.

Axes of elevation affecting the Formation.—Seeking by the study of the external phenomena of a formation, to understand either the revolutions in the past physical condition of its district, or the present structure of that portion of the earth which it constitutes, we shall find it essentially important to examine in an early stage of the inquiry, the nature, extent, and relative situation or direction of all the *axes of elevation*, which may disturb its beds from their original nearly horizontal position. These axes of elevation, marking the lines along which the subterranean forces have exerted themselves in their greatest energy, are the surest guides we can possess, not merely to the changes which the strata may have undergone, both of displacement and of alteration of structure; but to the existing position of every thing they may regularly include, whether it may interest science only, or prove particularly useful to the wants of man. They show us what portions of the formation have become deeply buried beneath the surface, and often at what depths, whether accessible or inaccessible, and they inform us what portions of the formation have been removed from the surface, by the crushing and washing away of the strata along the lines where they were most uplifted. They constitute, in fact, an indispensable clue to the operations of the miner, the quarryman, and even the road-maker, in every much convulsed district where they may abound.

As, therefore, the primary chain of the State, and the whole of the great valley which borders it upon the northwest, are traversed longitudinally by a most extensive system of such axes, lying mutually parallel and closely contiguous, and connected intimately with nearly every point in their geological structure, both general and local, I deem it important to introduce here a systematic enumeration of all such as are of much note, intending, as I proceed, to exhibit their relations to the disturbances and changes of structure, caused in the adjoining strata.

Pursuing our usual course, from the northeast towards the southwest, and examining first the southeastern belts of the forma-

tion in the Kittatinny Valley, we commence with that axis, or rather, probably, that chain of axes, which we find ranging in the prolongation of the Pochuck Mountain.

That the oval-shaped primary hill, called the Pochuck Mountain, owes a part at least of its present altitude, to an axis of elevation passing through it longitudinally from north-northeast, to south-southwest, is rendered sufficiently apparent by the anticlinal posture of the limestone reposing at its base; that which flanks it on the southeast dipping towards the Pochuck Valley; while that at its northwest foot has an inclination towards the valley of the Wallkill, in the opposite direction. The valley of Black and Warwick creeks, which I here call the Pochuck Valley, contains the limestone in a trough, considerably disturbed, however, from a symmetrical synclinal structure by a series of igneous dikes of mineral matter, ranging at broken intervals, at a nearly straight line from Amity, in New York, to a point a little south of Hamburg, which either locally derange, or altogether obliterate the dip of the limestone by fusion and recrystallization. The prolongation past Hamburg of this synclinal axis, is not clearly traceable, in consequence, most probably, of the close approach of the uptilting primary rocks of the Hamburg Mountain to those of the Pochuck Mountain; at this vicinity the upheaving influence of the former countervailing, for a limited space, the anticlinal axis of the Pochuck Mountain, causing all in the tract immediately southwest of Hamburg to dip along a certain distance towards the northwest. But tracing what ought to be the line of the Pochuck axis, a little further towards the southwest, we find distinct evidence throughout a belt having a somewhat confused anticlinal dip, of its prolongation under the limestone between Hamburg and Munroe. It would seem not to extend as far as the turnpike, south of the village of Lafayette; for though the limestone displays a northwestern dip along the margin of the slate, both at Munroe and on the turnpike, we cannot find in the proper places any corresponding dip to the southeast, which might give proof of a continuation of the axis so far towards the southwest.

Another axis of elevation is traceable in Pimple Hill, for the limestone at its southeastern base is seen dipping from the hill, or towards the southeast; and we have already recorded the north-

western dip of its beds on the western side, or between Munroe and the turnpike. Though the stratification is locally much contorted and disturbed in the valley between Pimple Hill and Hamburg Mountain, by the violent disrupting igneous agencies, which have so extensively altered the texture of the limestone, yet the general structure of this belt is that of a somewhat irregular synclinal trough, which may be traced past Sparta into the valley of Lubber run, though with many interruptions to the regularity of the synclinal axis. The portion of this valley between Sparta and Lockwood owes the uplifting of its beds, along the northwestern side, to an axis occupying longitudinally the narrow primary ridge which stretches from Sparta to Andover village.

The dip of the limestone becomes, however, very irregular as we approach the several insulated primary knobs in the vicinity of Lion Pond and Panther Pond, and between these and Stanhope. Just north of Panther Pond, the little limestone which is visible is seen to dip towards the northwest, evidently thrown off into that position from an axis in one of these knobs. Whether the axis of the Sparta ridge, that of the knob south of the pond, and that traversing the ridge which passes Alamuche, belong to one line of elevation, or whether, more probably, they are discontinuous, is a point not readily settled, owing to the obscure exposure of the limestone and gneiss, which are here much covered by diluvium, and to the remarkable intricacy of the country between Lockwood and Andover village.

Between Panther Pond and Lockwood, though there are probably several contiguous short anticlinal axes in the primary knobs, including, no doubt, intervening troughs of the limestone, yet this rock has been subsequently so affected by extensive igneous agency in this quarter, as to show an almost total loss of regularity in its dip.

Prolonging our observations southwestward, we find in the comparatively broad tract of primary rocks, which lies between Lockwood and Vienna, indications of more than one axis of elevation in the gneiss. The most southeastern of these has upheaved the limestone rocks of the northwestern side of the Hacketstown Valley, imparting to them their present dip to the southeast. This axis has probably brought to the surface, the narrow tract of gneiss, extending from Hacketstown towards

the Mount Bethel Church, pursuing the same line of elevation, namely, that immediately west of Musconetcong Valley, we trace the same anticlinal line, or more probably, one parallel and nearly continuous with it, through what is termed the Mansfield Valley. This is properly the axis of the upheaved belt of gneiss which lies between the Musconetcong and Pohatcong streams. We have proofs that the elevatory force extended southwestward, nearly to the Delaware, inclining the beds of limestone, on the one hand, towards the Musconetcong; and on the other, towards the Pohatcong.

That this axis of elevation is not strictly coincident with that which comes in to meet it from the northeast, is rendered likely by the variable undulating dip of the rocks along the centre of the Mansfield Valley, where these axes should pass. It is a phenomenon which the geologist may often have occasion to remark when detecting the near juxtaposition of two anticlinal axes which overlap or pass each other, that the strata immediately within its range are almost invariably thrown in a succession of opposite or undulating dips.

To the southeast of the general axis of elevation, viewing it as one, thus traceable from near Lockwood to the Delaware, we have the singularly uniform straight and narrow synclinal valley of the Musconetcong, along nearly the whole length of which the limestone will be found dipping away from the hills which bound it towards a synclinal axis, which ranges not exactly along its centre, however, but lies nearest to its southeastern margin, approaching the stream itself. This departure from a central position in the synclinal axis of the valley, is a very usual feature in the axes of the Appalachian chain. It results as a necessary consequence from the northwestern dips belonging to the anticlinal axes lying next to the southeast, or that of the Schooley's Mountain chain, being steeper than the southeastern dips from the axis of elevation northwest of it. This want of symmetry in the dip of the strata would not claim a special mention in this place, but for the truly remarkable circumstance, that throughout nearly the whole length of the Appalachian chain, embracing many hundred anticlinal axes, the same rule prevails with scarcely an exception, the northwestern dips being steeper than the opposite southeastern ones.

Resuming our delineation of the anticlinal axes which affect the limestone formation of the Kittatinny Valley, the next in order which plainly manifests itself to the northwest of the general line of elevation already described, belongs to the small ridge of primary rocks which runs very nearly in the prolongation of Pimple Hill, southwestward from the turnpike towards Long Pond. South of the pond, this axis is distinctly traceable in the limestone nearly to the next turnpike, which passes through Andover. If this and the axis of Pimple Hill are not identical, they are most probably the joint results of one elevatory force, exerted along a nearly *continuous* line. West of Andover, this line of elevation in the limestone is no longer traceable, the dips of the rock on the northern side of the Pequest being referable to the more influential axis which is prolonged from the violently uplifted ridge of Jenny Jump.

Between the short axis now described and that of the Sparta ridge southeast of it, we meet with a narrow belt of limestone, coming to a point towards Pimple Hill. In this belt, which opens out towards the southwest in the more expanded synclinal basin, southeast of the Jenny Jump axes, the limestone is much disturbed, and along its eastern side is in some places entirely crystallized by igneous agency.

The axis of elevation which passes longitudinally through Jenny Jump, is plainly exposed in the limestone for several miles in both directions. At the southwestern extremity of the ridge it passes to the south of the little village of Sarepta, and parallel with the base of Scott's Mountain towards Belvidere, forming a small synclinal basin in the secondary rocks, between Bridgeville and Belvidere. Along this anticlinal axis, especially near the mountain, the beds of the limestone are highly uplifted, and in many places, greatly crushed.

The movement which elevated Jenny Jump, seems to have been every where one of excessive suddenness and violence, as the strata along its anticlinal axis are not only there frequently much dislocated and broken, but those lying immediately along its northwestern base, are in several places thrown into an inverted posture, dipping, not to the northwest, but in towards the base of the hill.

Tracing this anticlinal axis towards the northeast, we find it

exhibited in very steep, and somewhat disturbed dips in the limestone, for a short distance beyond the termination of the mountain. It afterwards becomes more regular, and may be discovered running for many miles in a nearly straight course, passing a little to the east of Greenville. Between this point and the turnpike, we fail to follow it in consequence of the difficulty of procuring distinct exposures of the strata; but about a mile northeast of the turnpike, we perceive an anticlinal axis, ranging somewhat parallel with and northwest of Long Pond, and coinciding so nearly in direction and position with this of Jenny Jump, as to warrant us in regarding it as a portion of the same line of elevation near its northeastern termination. Were this axis prolonged yet further to the northeast, it would constitute one long and nearly straight axis with that which approaches it from the northeast, through the centre of Pochuck Mountain; but as we have already shown that the latter subsides near Munroe, we have a space of several miles along which their continuity is interrupted.

Adverting now to the synclinal basins, included between this main axis of Jenny Jump and the chain of axes previously traced, lying to the southeast of it, we discover the limestone to form one general trough, in the valley of the Pequest, between Greenville and the Alamuche belt of the primary. But passing the Andover turnpike, this trough runs into two, on account of the interposed short anticlinal axis, prolonged from Pimple Hill. Between the anticlinal axis and Alamuche, the southeastern dips are observed to occupy, as they frequently do, a much *wider* belt than the northwestern one, the latter being by far the *steepest*. Whether farther towards the southwest, between Jenny Jump and the ridges east and south of the little village of Vienna, the limestone of this tract may not be disturbed from the simple synclinal arrangement which it has near Alamuche, in consequence of one or more short axes of elevation extending into it from the spurs of Scott's Mountain, is a question not readily answered, owing to so large a portion of the surface of the limestone being hid from view, first by the Great Meadow, and southwest of this, by the large accumulations of diluvium in that quarter.

That such short axes do disturb the limestone near Scott's Mountain, is, however, highly probable, even from the few dips disclosed.

Though it is difficult to trace the axes of elevation as they traverse the primary ridges, on account of the frequency of the igneous injections in the gneiss producing much contortion in the strata, yet viewing the topography of Scott's Mountain in connexion with the more regular dips which it discloses, we cannot resist the impression, that it owes its elevation to at least two considerable anticlinal axes.

One of these would seem to range along its southeastern ridges, passing not far from Oxford Furnace, and southwestward between the Lopatcong and Merrill's brook, affecting the limestone north of the former stream. The other observes a more northwestern line, and is probably connected with the elevation of the primary ridge, called the Marble Mountain, at the Delaware. At the southeastern base of Scott's Mountain, we find the limestone assuming the synclinal structure in the valley of the Pohatcong; but not every where symmetrically, as it gives evidence, especially as we approach the Delaware, of being in some places actually *inverted* along its southwestern border.

It is difficult, indeed, to find the rocks any where dipping to the northwest, throughout the whole distance from the Pohatcong, across their strike, to the base of Marble Mountain. This indicates, in the Kittatinny Valley, that those belts of the stratum lying to the northwest of each anticlinal axis, instead of assuming, as we would expect, a northwestern dip, have been so forcibly upheaved in that direction as to have been tilted in many cases *beyond* the vertical plane, and made to fold over, with a southeast dip, upon the southeastern dipping beds belonging to the next northwestern axis. Connected, most probably, with some early movement of elevation in the strata around Jenny Jump, there occurs an interesting and rather unusual phenomenon, in the narrow belt of limestone at the base of the mountain, immediately to the southeast of the little village of Hope. We allude here to the uncommon structure of the rock, which is at this place a true conglomerate, made up entirely of pebbles and rotted fragments, some of them being many inches in diameter, which, like the paste imbedding and cementing them, consist exclusively of the same materials as the rest of the blue limestone formation, in which this conglomerate occurs as one of the interposed beds.

The same formation embraces, in Pennsylvania, a similar

included stratum, occupying, to all appearances, a corresponding position in the general mass of the limestone. This occurs on the Northkill, a little above the village of Bernville, in Berks county: these are the two principal localities at which I have hitherto discovered this coarse, calcareous conglomerate. But I am authorized by my brother, Professor William B. Rogers, the state geologist of Virginia, to mention, that an equivalent rock prevails in the same relative place in the geological series, at several points along the Kittatinny Valley in that State.

This conglomerate imparts interest to all inquiries respecting the *date* of the disturbances which have elevated our great series of Appalachian rocks, throughout their prodigious range, from Vermont to Alabama: it distinctly implies that the shores of the Appalachian ocean were agitated at the early epoch at which the limestone was produced, by a movement sufficiently violent to shatter and convert into pebbles some of that rock already deposited.

The facts above adduced, prove, also, that, though apparently sudden and of short duration, this convulsion of the limestone ranged, if not uninterruptedly at least at intervals, far to the southwest, along the same line of ancient shore: for it is indisputable, that the general belt of the Highlands, and their prolongation southward, formed the general southeastern coast of the great ancient secondary or Appalachian sea, if not every where at the *commencement* of these deposits, certainly after the first two or three formations were accumulated.

The next main axis of elevation beyond that of Jenny Jump, is traceable from near Deckertown southward, passing the villages of Harmonyvale, Lafayette, Newton, and Johnsonburg. Strict continuity of the anticlinal axis between these several points is not, however, clearly established; and, very possibly, it is rather a succession of two or three coincident axes than one of unbroken regularity: the upheaved belt of limestone containing this chain of axes is itself uninterrupted from the Wallkill, near Deckertown, to Johnsonburg, its northwestern margin; and that of the belts on its southwestern prolongation, at Hope and Belvidere, have been delineated in detail when describing the geographical range of the formation. On the southeast, between this anticlinal belt of the limestone and that which contains the axes of the

Pochuck and Jenny Jump Mountains, there is a long and narrow zone of the overlying slate, Formation III. This starts from the Wallkill, about three miles northeast of Deckertown, and ranges in an attenuated ridge, until opposite Newton, passing about half a mile east of Harmonyvale and Lafayette. It presents throughout its whole length a regular synclinal structure, lying in the middle of the trough of limestone, formed by the two parallel anticlinal axes above referred to. About four miles southwest of the termination of this narrow range of slate, another commences, beginning between Reading's Pond and the turnpike, and passing a little west of Greenville. Between this belt, which is very narrow, and Grass Pond, near the anticlinal axis, occurs another similar small range of the slate. The two parallel little ridges of this rock lie in the prolongation of the general synclinal trough, between the two main anticlinal axes, separated, however, by a short interposed axis of elevation, traceable between them from Reading's Pond, southwestward. Each belt of the slate has, therefore, the structure of a narrow synclinal ridge.

Lying a little further to the northwest than the principal axis, which passes Johnsonburg, there commences an axis which elevates the limestone of the oval tract, extending from near Johnsonburg nearly to Sarepta.

The axis to which we now allude passes a little northwest of the village of Hope, dying out beneath the slate towards Sarepta. Between it and the northwestern dipping limestone, uptilted by the axis of Jenny Jump, we may trace another long, narrow, and nearly straight belt of the slate. This small ridge of the slate, like those previously mentioned, contains a synclinal axis running centrally along it.

Besides the anticlinal axis which ranges a little northwest of Hope, we have indications of another shorter one, lying between it and the western margin of the limestone. But this lesser axis, the presence of which explains the sweep towards the westward at this place, at the edge of the upheaved rocks, has not been accurately traced, owing to the fewness of distinct exposures.

The last of the main anticlinal axis of the Kittatinny Valley towards the northwest, is that of the limestone belt of the valley of the Paulinskill.

This axis may be pursued for nearly the whole length of this

limestone valley, from northeast of Augusta to the Delaware river. Its usual position is somewhat to the southeast of the middle of the valley. Like many of the others, upon its southeast it is not always symmetrical, the strata on its two sides dipping at different degrees of inclination, and being, besides, often separated by either a crush of the rocks near their turn, or by a partial dislocation immediately at the axis.

West of Newtown the general belt of limestone is traversed, for a space of several miles, by a narrow tract of the slate, causing its northeastern termination to be in the form of two wedge-shaped prongs, one ending near Courserville, the other about three miles north of Newtown.

This southeastern branch, from the main tract of the limestone, contains, we have reason to believe, a lesser parallel anticlinal axis, the cause, indeed, of the elevation of the limestone along this line. Between it and the main axis, a little southeast of Swartwout's Pond, all the rocks have a synclinal arrangement, the belt of slate lying in the middle of the trough of the limestone.

Tracing the principal axis of the Paulinskill Valley beyond the termination of the limestone near Courserville, we find it running for several miles further towards the northeast, until it passes a little west of Deckertown, elevating the beds of the slate.

The limestone valley of the Paulinskill corresponds accurately in its general physical features with what is termed a valley of elevation.

Its strata having been upheaved along a central anticlinal axis, the surface of the valley is somewhat raised in the centre, and depressed along both margins, while the overlying and surrounding strata of slate, less broken and denuded than the limestone, encompasses it in a regular escarpment, giving to the whole the true structure of a valley of elevation.

A much broader zone of slate is interposed between the Paulinskill axis and that of the Newtown Valley, than between this latter and the axis of the Jenny Jump and Pochuck range. This is obviously the result of a twofold cause, the greater interval which separates the two northwestern axes, and the less amount of vertical elevation in the strata adjoining them: leaving, therefore, both a broader and deeper synclinal trough in the slate to resist the denuding agency of the currents, which have swept

off so large a portion of the upper strata from the Kittatinny Valley. Between Belvidere and Columbia, on the Delaware, the tract of slate, which is here several miles in breadth, exhibits numerous local changes of dip, the result probably of a series of lesser anticlinal axes, which may traverse this end of the belt. The oblique cleavage planes are so conspicuously displayed in this part of its range, as to efface, very generally, all distinct traces of the true stratification, rendering the determination of its axes a work of extreme uncertainty. The simple synclinal structure of this belt opposite Newton and Augusta may, however, be readily established by a close attention to the true dip of the rocks.

Only two other ranges of the lower Appalachian limestone, besides those already referred to, occur within the State. These are, the belt traversing German Valley and its extension, and the small patch in the valley of Mendham. Both of these have been previously adverted to, as occurring in the form of narrow synclinal basins, included between the adjacent ridges of the primary rocks. The upheaving of these latter, by a series of axes of elevation difficult to trace in detail, has manifestly given to the limestone its synclinal posture in the intervening valleys, where this rock obviously once spread itself over much wider tracts than at present.

Igneous Rocks connected with Formation II.

Of the changes induced upon the limestone by igneous action.— The blue limestone of the Kittatinny Valley exhibits, in certain localities, some highly impressive and remarkable phenomena of alteration of structure, induced by the heating agency of a series of igneous injections. The altered bands of the rock may be correctly grouped into two distinct belts, ranging from northeast to southwest, parallel to the general strike of all the strata in this quarter of the State. The more northeastern of these belts occupies, at intervals, the valley which lies immediately at the foot of the Hamburg or Wallkill Mountain, throughout nearly its whole length, keeping usually towards its northwestern margin, or near the base of the Pochuck Mountain, and the belt of hills in its prolongation to the southwest, namely, the hills north of

Franklin, Pimple Hill, and the hills north and west of Sparta and Lockwood.

That further to the southwest commences at the northeastern extremity of Jenny Jump, and follows the southeastern base of this mountain throughout nearly its whole length, beyond which, after an interruption of about two miles, it again occurs near Oxford; and further still, at intervals, near Concord and Davidson, where it is within two miles of the Delaware. Traced longitudinally, the altered rock shows itself not so much in one continuous line, as in a succession of long, narrow, and somewhat detached belts, several of which sometimes lie parallel to each other and closely contiguous.

The northeastern tract first shows itself at Mounts Adam and Eve, in New York, about five miles beyond the state line, and has its southwestern termination in the neighbourhood of Lockwood. Over this whole distance, though the altered material exhibits considerable diversity in regard to the imbedded minerals which it contains, yet the main mass of the rock, or the calcareous paste investing them, retains to a great extent, a uniform character as to colour and structure.

When destitute, or nearly so, of the extraneous minerals often diffused through it, the prevailing condition of the rock is that of a white, perfectly crystalline limestone. An extreme degree of developement of the crystalline structure, is when the mass had assumed the condition of rhombic calcareous spar. It is then often semitranslucent, but more frequently it is of an opaque white, and occasionally of a pink hue, resembling somewhat reddish felspar. These varieties may be regarded as the altered rock under its most characteristic features, and are to be viewed as exhibiting the *limit of alteration* of which the limestone has been susceptible by igneous action, where it has been *pure*, or consisted of little else than carbonate of lime. When of such aspect and structure, the mineral most usually disseminated through it is *plumbago*, in small brilliant plates, often perfectly hexagonal. Besides this highly developed crystallization, it presents every gradation of crystalline structure down to a finely granular one, and even to what may be termed the subcrystalline condition, when it often partakes of the colour and texture of the blue limestone, out of which all these varieties have origi-

nated. Clouded, veined, and spotted, by various mineral matters mingled through it, and frequently susceptible of an excellent polish, it promises to furnish, if attainable in masses of sufficient size, a material of superior beauty for ornamental purposes in architecture. Various foreign minerals blend themselves occasionally through the substance of the calcareous rock in every possible proportion, from a few sparse crystals to such an abundance as almost to replace the calcareous matter, which then merely fulfils the part of a cement.

These minerals, several of which are rare in the cabinets of the mineralogist, constitute a list, when all are enumerated, of considerable extent. Those which chiefly predominate, and which tend by their prevalence to impart a certain uniform mineral character to the altered limestone, are: *Condrodite*, or Brucite, in orange-yellow crystals; *augite*, common and crystallized; *plumbago*, foliated usually in six-sided scales; *spinelle*, often in octohedral crystals; *sahlite*, and *mica*.

The following catalogue, by Dr. Fowler, of Franklin, who has zealously contributed to draw the attention of mineralogists to this interesting region, exhibits a sufficiently detailed list of the minerals hitherto discovered in association with the altered limestone:

"*Franklinite.*—A new metalliferous combination, containing, according to Berthier, of oxide of zinc 17, of iron 66, and manganese 16 parts, is very abundant, indeed it appears inexhaustible. It commences about half a mile northeast of Franklin Furnace, and extends two miles southwest of Sparta, a distance of nine miles. It is accompanied in this whole distance by the red oxide of zinc, mutually enveloping each other. The greatest quantity appears to be at Franklin Furnace. The bed here is about one hundred feet high above the adjoining land, on the west side of it, and from ten to forty feet wide. Various attempts have been made to work this ore in a blast furnace, but without success. It frequently congeals in the hearth before time is allowed to get it out in a liquid state, in consequence of a combination of the iron with manganese. All this difficulty, I apprehend, might be overcome, if a method could be discovered of smelting iron ore in a blast

furnace with anthracite coal; as the Franklinite requires a greater degree of heat to cause it to retain its liquid state, than can be obtained by the use of charcoal. It occurs in grains, imbedded in the white carbonate of lime, and detached in concretions of various sizes, from that of a pin's head to a hickory nut; also in regular octohedral crystals emarginated on the angles, small at Franklin, but very perfect, with brilliant faces. At Sterling, the crystals are large and perfect. I have one from that place that measures sixteen inches around the base.

"*Red Oxide of Zinc.*—At Sterling, three miles from Franklin, a mountain mass of this formation presents itself about two hundred feet high. Here, as Mr. Nuttall truly observes, the red oxide of zinc forms, as it were, a paste, in which the crystals of Franklinite are thickly imbedded; in fact a metalliferous porphyry. This appears to be best adapted for manufacturing purposes. The Franklinite imbedded in the zinc ore here, is highly magnetic, and may be all separated by magnetic cylinders, recently brought into use to separate the earthy portion of magnetic iron ore. It was long since observed, that this ore is well adapted for the manufacture of the best brass, and may be employed without any previous preparation. It is reduced without any difficulty to a metallic state, and may be made to furnish the sulphate of zinc (white vitriol.) Berthier found it to contain oxide of zinc 88, red oxide of manganese 12.

"*Magnetic Iron Ore.*—On the west side of the Franklinite, and often within a few feet of it, appears an abundance of magnetic iron ore, usually accompanied by hornblende rock. In some places it soon runs into the Franklinite, which destroys its usefulness; and the largest beds are combined with plumbago, which renders it unprofitable to work in a blooming forge, but valuable in a blast furnace.

"The other minerals found in this district are numerous, rare, interesting, and several of them new, and not found in any other place, but better calculated to instruct the naturalist and adorn his cabinet, than for any particular uses to which they have as yet been applied. A catalogue which I have subjoined, designates the minerals as they occur in each township.

"In *Byram Township*, considered the southwestern extremity

of the white carbonate of lime, occur: Spinelle, colour reddish-brown, green, and black, in octohedral crystals, associated with orange-coloured Brucite. Brucite of various shades, from that of a straw-colour, to dark-orange, and nearly black. Gray hornblende, in six-sided prisms, with dihedral summits.

"In the *Township of Hardiston.—At Sparta:* Brucite of a beautiful honey-colour: the finest we have is found here. Augite, in six-sided prisms; colour brownish-green.

"*At Sterling.*—Spinelle, black, green, and gray, in octohedral crystals. Brucite of various shades. Rutile; colour steel-gray; lustre metallic, in acicular prisms, with longitudinal striæ. Blende, black and white; the white sometimes in octohedral crystals, the lustre brilliant. Dysluite, in octohedral crystals; colour brown externally; internally yellowish-brown; lustre metallic (a new mineral). Ferruginous silicate of manganese, in six-sided prisms, colour pale-yellow; associated with Franklinite. Tourmaline, imbedded in white felspar, in six-sided prisms; longitudinally striated; colour reddish-brown. Green and blue carbonate of copper. A number of large excavations were made at the Sterling Mine for copper, during the revolutionary war, under an erroneous impression, that the red oxide of zinc was the red copper ore. It was the property of Lord Sterling; hence the name of the Sterling Mine. Of copper, we only find there a trace of the green and blue carbonate.

"*At Franklin.*—Spinelle, black and red crystallized. Ceylonite, green and bluish-green, in perfect octohedrons, truncated on the angles; lustre of the brilliance of polished steel. Garnets, black, brown, yellow, red, and green, crystallized in dodecahedrons. Silicate of manganese, light brownish-red. Ferro-silicate of manganese, of Professor Thompson, and the Fowlerite of Nuttall, light red or pink, foliated and splendent; has much the appearance of felspar; is also in rectangular prisms. Sesquisilicate of manganese, lamellar in scales or small plates; colour brownish-black. Hornblende, crystallized. Actynolite, crystallized. Tremolite, crystallized. Augite, common variety, crystallized. Jeffersonite, common variety, crystallized. Plumbago, foliated and crystallized in six-sided scales. Brucite of various shades. Scapolite, white, crystallized. Wernerite, yellow, crystallized. Tourmaline, black,

crystallized. Fluate of lime, earthy and crystallized. Galena. Oolite, in small grains about the size of a mustard-seed, disseminated in blue secondary carbonate of lime. Asbestus, connected with hornblende rock. Green beryl. Felspar, green and white, crystallized. Epidote and pink carbonate of lime. Arsenical pyrites. Serpentine. Sahlite. Cocolite, green and black. Sphene, honey-colour, crystallized. Quartz. Jasper. Chalcedony. Amethyst crystallized. Agate. Mica, black and orange-coloured, crystallized. Zircon, crystallized. Sulphate of Molybdena. Phosphate of iron. Carbonate of iron. Steatite, foliated, with yellow garnet. Phosphate of lime crystallized. Pale yellow blende, of a foliated structure, lustre, vitreous.

"*Near Hamburgh.*—An ore of manganese and iron, of a light reddish-brown, very compact and heavy. Augite and Brucite.

"*In the Township of Vernon.*—Green spinelle and Brucite, in octohedral crystals.

"*In Newton Township.*—Sulphate of barytes in lamellar masses, and tabular crystals, in a vein traversing secondary limestone. Sapphire, blue and white, in rhombs and six-sided prisms. Red oxide of titanium. Gray spinelle in large octohedral crystals. Mica, copper-coloured, in hexahedral crystals. Idocrase, crystallized, yellowish-brown. Steatite, presenting the pseudomorphous form of quartz, scapolite, and spinelle. Scapolite, in four-sided prisms.

"For a more particular account of the Newton minerals, see Silliman's Journal, vol. xxi. page 319.

"*In Frankford Township.*—Serpentine, of a light yellowish-green, bears a fine polish, has a glistening lustre, and is quite abundant."

On the Franklin or Warwick mountain, about four miles east of the furnace, are numerous beds of iron ore, from which many thousand tons have been taken; and which still contain a large quantity of the best quality of ore, either for a blooming forge or blast furnace. Iron pyrites occurs here, both in the valley and on the mountain, of a proper quality to manufacture sulphate of iron (copperas). It also occurs crystallized, in cubes, in octahedrons, and dodecahedrons, frequently perfect and highly splendid.

Following the range of the crystalline limestone somewhat more in detail, we shall commence our description of its geological features where it first conspicuously shows itself, in the neighbourhood of Amity, in New York. Here, and for several miles to the southwest, the belts of altered rock occupy a very considerable width, in the valley ranging from Mounts Adam and Eve towards Hamburg, forming a zone averaging, at first, half a mile in breadth, but contracting to two or three hundred yards. The crystalline material in its most perfect form, does not, however, fill the whole space, but occupies rather a series of closely adjacent parallel bands, most numerous towards the middle and northwestern side of the valley, where a chain of low irregular ridges usually contain the limestone in the highest state of crystallization. These evidently mark the existence of a series of parallel veins of igneous origin, the intrusion of which into the limestone, have obviously caused its alteration. Between the base of the Wallkill Mountain and the crystalline rock towards the middle of the valley, we usually meet with beds of the formation which evince but a partial amount of change from the igneous action; the limestone retaining more or less of its bluish tint, and presenting only a subcrystalline, or even the ordinary earthy, texture. These less altered beds, reposing upon the gneiss of the Wallkill Mountain, dip towards the northwest. Towards the base of the Pochuck Hill, on the other side of the valley, the limestone would seem to have undergone a more extensive alteration. Approaching Hamburg, the crystalline belt contracts considerably in width. About two and a half miles northeast of that village, we find it occupying a broken chain of long, narrow, irregular ridges of considerable elevation. These range parallel with the base of the Pochuck Mountain, separated from it by a tract of low meadow ground, about three hundred yards in breadth. In this belt the altered limestone is in great confusion; the calcareous crystalline matter being mingled largely, in many places, with a white friable sandstone, referable, obviously, to Formation I., the position of which, when it occurs at all, is immediately beneath the limestone. The fused calcareous matter seems in some cases to have penetrated the substance of the sandstone. The height of this ridge or chain of ridges may be stated to average about two hundred feet;

the width at the base being not less than a fourth of a mile, and the length rather more than one mile. Besides the mass of altered limestone, these ridges comprise portions of Formation I., together with beds of the gneiss, both in a highly disordered and shattered condition, with more than one extensive dike of igneous matter, the immediate cause, most probably, of these disturbances.

From the confusion which accompanies all these rocks, none of them can be found, even for a short distance, possessing any regularity of dip.

The gneiss rocks of the Pochuck Mountain, on the contrary, are distinctly seen dipping steeply towards the valley to the southeast.

The most conspicuous display of the crystalline limestone is at the two extremities of the ridge which lie nearest Hamburg. Between these points, towards its central portion, the same ridge contains a large well-known deposit of brown or hematitic *iron ore*, occupying its summit and sides, and penetrating deeply into the body of the hill; details regarding this valuable iron mine will be given under another head.

Separated from the Hamburg belt of altered limestone, by a spur of the Wallkill Mountain, there exists another band of the crystalline rock on the Sand Pond creek, about one mile and three quarters southeast of Hamburg. This commences near the southwestern termination of a small knob of gneiss.

Though highly crystalline, the limestone still retains considerable regularity of stratification, dipping towards the west-northwest, at an angle of 20°, being well exposed in a quarry, (the property of Wm. Edsall,) where it is used for making pure lime. It is white, and highly crystalline, and contains disseminated scales of graphite. This line of altered rock ranges south-westward nearly to the turnpike, and is met with again on the road to Sparta, about half a mile beyond the turnpike.

Between the small knob of gneiss, above spoken of, and the Wallkill Mountain, to the southeast, we meet with another deposit of brown or hematitic iron ore, a little beyond the termination of the crystalline limestone, none of which, however, is discovered near it. This ore will be more minutely described in another place.

To the northeast of this altered belt we trace another, occupying the northwestern side of the Mine Hill, east of the Wallkill stream, a long narrow point of primary rocks, extending from Pimple Hill to within about three miles of Hamburg. Not far from the northeast termination of Pimple Hill, and near the old Franklin furnace, we encounter, in the northwestern side of the Mine Hill, next the valley of the Wallkill, a narrow belt of common gneiss rock, dipping, as usual, to the southeast. Reposing upon this, with a conformable dip, is seen a highly interesting mineral vein composed of impure *magnetic iron ore*, *Franklinite*, *Garnet*, *Jeffersonite*, and several other crystalline minerals, blended, especially near the borders of the mass, with the crystalline limestone, much darkened and changed from its ordinary appearance, by the amount of combined mineral matter; much of this calcareous portion of the vein is pervaded by small granular crystals of the *Franklinite*. The whole vein has a thickness of several feet.

Immediately east of this metalliferous vein, there rests, in the main body of the hill, a broad belt of the white crystalline limestone, preserving its original, rather steep, southeastern dip. The position of the vein here, is therefore, as in the majority of instances in the region, intermediate between the primary strata and the beds of altered limestone, which, notwithstanding the partial fusion and intense heat to which it has been subjected, still furnishes distinct traces of its lines of deposition.

Towards the eastern declivity of the hill, the crystalline rock prevails in considerable purity, though it is often very free from foreign admixtures, even adjacent to the metalliferous vein. In this latter position, however, it is more frequently mixed with *quartz*, *felspar*, *sahlite*, *augite*, *hornblende*, and a great variety of minerals, some of which are common ingredients in the primary strata of the country. In the quartz, and near its contact with the limestone, *green spinelle* occurs.

The occurrence of so many of the minerals which are constituents of the adjoining *primary* rocks, both in the intrusive vein itself, and in the neighbouring portions of the altered limestone, is a fact of no little theoretical interest, as it leads us directly to views tending to explain satisfactorily the several sources of the numerous

and varied crystalline minerals found connected with the changes effected in the limestone.

At the summit of the ridge there is a seam of quartz rock, presenting some indications of its occurring as a vein in the white limestone. Its nature and origin cannot be proved, for it may be a vein of mineral matter strictly intrusive, or one of the beds of *chert*, so common in the limestone, or a portion of Formation I., completely fused by contact with the intensely heated metalliferous vein. The confused arrangement and varied aggregation of the altering and altered materials at this place, render it next to impossible to trace the true relationship subsisting between some of the parts comprised in this curiously heterogeneous belt of mineral matter. The vein, in its course to the southwest, undergoes a considerable change in its character. About two hundred yards southwest from the place already mentioned, it appears to consist almost wholly of *garnet rock* and *Jeffersonite*, some of the latter occurring in enormous crystals, projecting from the face of the rock, but so fissured and readily broken as to render it difficult to procure them entire.

Further still to the southwest, and nearly opposite the Old Forge, are considerable excavations made in former times for *iron ore*. The ore was far from pure, abounding in *Franklinite;* which by the *manganese* and *zinc* contained in it seriously interfered with the conversion of the ore into iron. This ore includes, moreover, a considerable proportion of the *red oxide of zinc*, in some places remarkably pure, being finely lamellated and unassociated with any of the *Franklinite* that generally accompanies it, and which interferes effectually with its reduction into metallic zinc on the large scale.

Could this pure red oxide be obtained in sufficient quantity, it would probably be better adapted for smelting into zinc than the mixed ore of the Sterling Mine, three miles further to the southwest. This somewhat rare ore of zinc, the crystallized red oxide, occupies, in company with the crystallized Franklinite, a metalliferous vein, or more probably a line of nearly continuous veins, in the crystallized carbonate of lime, extending, with occasional interruptions the whole distance from Franklin to a little beyond Sparta, a total length of more than eight miles.

The catalogue already presented, compiled by Dr. Fowler of Franklin, supplies a nearly complete list of the other minerals found in this part of the igneous and altered zone of rocks.

From Franklin we may trace the white crystalline limestone continuous to Sterling, about three miles to the southwest.

Here we find it lying in contact with a remarkable vein consisting exclusively of Franklinite and the *red oxide of zinc;* he former in crystalline granules, often approaching the ochtoedral form, invested by a paste of the zinc ore, which frequently constitutes more than one-half of the mass. The position of this ein is on the eastern declivity of a hill of considerable elevation, here it occupies the same intermediate relation to the gneiss nd crystalline limestone which was mentioned of the vein at Franklin.

At Sterling, the metallic vein, where it is visible at the surface, ests with a steep southeast dip *conformably* upon the steeply-ipping beds of gneiss, rising in the form of a bold cliff or wall long the side of the hill. Against this wall of ore, and at the ase of the hill, repose the beds of the white altered limestone, resenting unequivocal traces of its original planes of stratification, howing the sedimentary origin of the rock. It obviously dips t the same inclination of from 70° to 80° to the southeast, with ie vein and the gneiss upon which it lies.

The metalliferous vein is from eight to ten feet in thickness, nd consists of no other minerals but the Franklinite and ore of inc. From its exposed position on the flank of the hill, the ore ould be excavated to an almost indefinite extent with a facility nusual in the history of mining operations. Zinc of an admirably ure quality has been prepared from this ore by Mr. Hitz, under ie directions of Mr. Hasler, for the manufacture of the brass or the standard weights and measures now making by the latter cientific gentleman for the several custom-houses of the United tates, by order of Congress. An economical method for the eparation of the zinc from the Franklinite in this ore, still emains, however, a desideratum in practical metallurgy.

Between Sterling and Sparta, the belt of crystalline limestone is traceable with but little interruption nearly the whole distance, affording in some places specimens of a variegated marble of

uncommon beauty. It follows the eastern base of Pimple Hill to the southwestern termination of that ridge, and then appears nearly in the same line at several points on the west of the gneiss hills, west of Sparta, and also within a few hundred yards of the town itself. The narrow valley embraced between those hills and the Wallkill Mountain on the southeast, is in the immediate neighbourhood of Sparta, and for some distance southwest, occupied by the unaltered blue limestone dipping usually towards the northwest.

About a third of a mile northwest of Sparta, the white crystalline limestone crosses the turnpike road. This is one of the principal localities whence mineralogists have supplied their cabinets with specimens of condrodite or Brucite. A better locality, however, may be seen on the west side of the hill, about half a mile further north, where another exposure of the white crystalline limestone affords crystals of the Brucite and gray spinelle in an abundance and of a quality far surpassing those of any other spot yet discovered in this vicinity. At the same place might be opened inexhaustible quarries of variegated and pure white marble; some of the former promising to be, if polished, of uncommon beauty. Care should be observed, in establishing quarries in this rock, to choose those parts of the belt least shattered by the action to which it has been exposed.

Between three and four miles southwest from Sparta, on the northwest side of a low ridge of gneiss, we find a very interesting locality of the altered limestone, very nearly in the prolongation of the belt which passes along the southeast base of Pimple Hill. This spot is remarkable less for the extent or breadth over which the limestone has been affected by igneous action, than for the strikingly convincing evidence which it affords of the nature of the changes induced in the calcareous rock by the series of igneous veins and dykes which we have been tracing. The ridge itself, along the side of which the limestone has been altered, consists chiefly of a thinly-bedded *micaceous* gneiss. Through the summit, or rather on the northwestern flank, which is often abrupt and rugged, there rises a thick granitic dyke or vein of very heterogeneous composition, supporting the steeply-dipping beds of gneiss, whose usual inclination is at an angle of 80° to the

fusion, and, therefore, free to obey their several affinities, will readily explain the formation of these insulated crystalline nuclei. The mineral *condrodite* contains about 54 per cent. of *magnesia*, with about 38 per cent. of *silica*, besides trivial proportions of *oxide of iron*, *potash*, *fluoric acid*, and water. These suggestions, respecting the origin of the *condrodite*, receive support from the fact, that this mineral prevails in its usual uniform and moderate proportion through considerable ranges, longitudinally, of the altered limestone, even where not immediately contiguous to the injected veins, while in other parallel zones of the crystalline rock it is almost wholly absent. Thus, in the chain of sparry limestone which stretches at intervals from Sparta towards Lockwood, we find it almost constantly present, though never but in moderate quantity.

From several chemical analyses of the sparry, rhombic varieties of the rock containing only *graphite*, and of the white irregularly crystalline kinds enclosing the condrodite, we have still more conclusive evidence tending to settle this interesting point.

Resuming our progress towards the southwest, we next meet with a succession of detached ridges of the altered sparry limestone, in the valley between the Wallkill Mountain and the primary ridges southwest of Sparta; the latter tract of gneiss separating this belt from that previously described. These ridges first appear nearly four miles southwest of Sparta, at the extremity of an extensive meadow, and range towards Lockwood. They are four in number, the shortest being about one hundred yards long, while the longest exceeds a fourth of a mile. Their width is between two hundred and three hundred feet; they occupy one general line; but between their extremities is usually a space of from half a mile to a mile of primary strata, whose prevailing dip is towards the southeast, though under circumstances of great irregularity.

The white altered limestone of these ridges is rather in the condition of an amorphous crystallization, than in the form of rhombic spar. Such is the case at Franklin and Lockwood. It is in fact a coarse granular white marble imbedding many of the rare and beautiful crystalline minerals found at Amity and Franklin; we may mention *Brucite* and *green spinelle* of uncommon purity.

The series of changes here described may be considered as representing the phenomena in every instance, where superficial deposits have not concealed the vein, the blue limestone, and the intermediate altered belt. The locality above referred to is dwelt on in detail, chiefly because it furnishes a distinct exhibition of each successive stage of the change. The gradation is not more complete at this place than near many other dikes, but it is better exhibited within a small area.

The invariable occurrence of the *graphite*, in portions of the altered belt remotest from the dike, and its never existing in more than a very trivial quantity, even adjacent to the vein where the other extraneous minerals are frequently present in great excess, strongly imply that it has been derived from the elements of the blue limestone itself, which may easily be proved to contain an adequate quantity of iron and carbon for the production of this mineral.

It is not a little curious that, in some belts, the altered rock contains the mineral *condrodite*, in a precisely similar relation as to the degree of crystallization of the mass, and proximity to the vein of igneous matter; that is to say, when it first appears in the portions of the crystalline belt remotest from the line of injected minerals, it is in small imperfectly developed nuclei, which grow larger and better formed as we approach the quarter of more intense igneous action, but which, like the crystals of *graphite*, usually remain but sparsely disseminated through the rock. Showing a strong analogy, in its mode of distribution through the substance of the white limestone, to the nuclei or geodes of *epidote* and other minerals seen in the red shales where these have been baked and altered by the intrusion of dikes of heated trap, the *condrodite* seems to claim a corresponding origin to that generally attributed to the epidote, which is regarded as derived, in these cases, from the constituents of the rock itself. To trace the source of the *condrodite* upon this hypothesis, we have only to conceive that the injected mineral matter, in an igneous state, was poured through fissures in a limestone, possessing, what is very common, a siliceo-magnesian character; and the well known tendency to the production of specific mineral combinations, in a mass whose particles are in a state of at least semi-

Near Lockwood, not far out of the general line of the larger belts or ridges of the crystalline limestone already treated of, we come upon another band of the calcareous rock which has undergone alteration. Though of rather local extent, this spot is deserving of attention, if only for the perfection in which we here behold the translucent rhombic spar, into which the blue sedimentary limestone has been converted by the agency of heat. Disseminated through the spar, we find the *graphite* sometimes in regular hexagonal plates half an inch in diameter. From a large rhombic crystallization, the calcareous rock graduates to an amorphously crystalline limestone, or a white granular marble.

Some portions of the mass, especially those having the more highly developed crystalline character, include, besides the graphite, several minerals, as *Brucite, mica, talc, quartz,* and *green spinelle;* the mica being in some cases so abundant, as to imply probably its derivation from the contiguous gneiss rocks.

While alluding to the vicinity of Lockwood, it may be mentioned as an interesting locality of granular and crystalline *augite.* Some of the beds of the gneiss in this neighbourhood, being traversed by bands of a deep-green talcose mineral, pervading a mass consisting chiefly of lighter-coloured felspar, would furnish a building material of very beautiful appearance.

Having now described in sufficient detail the numerous bands of altered limestone comprehended in the one general belt of igneous action, which stretches in a nearly straight direction from beyond Amity, in New York, to its southwestern termination near Andover Forge, a little beyond Lockwood, I shall in the next place enter upon a more brief account of the shorter, but no less interesting belt, which pursues the southeastern base of Jenny Jump.

As in the instance of the altered rock near the eastern foot of Pochuck Mountain, the beds of the white crystalline limestone of Jenny Jump do not lie against the flank of the hill itself, but belong to a separate low narrow ridge, or rather series of ridges, parallel with its base, but at a distance sometimes of a few hundred feet. These ridges consist in part of the altered rock, and in part of a succession of intrusive dikes of what, from its general aspect and composition, may be termed a sienite rock,

Notwithstanding the prodigious extent of igneous action to which the limestone has been evidently exposed in these belts, manifested by the width of the space over which a total modification of the rock has been effected, we still discern a very distinct stratification, the beds dipping steeply towards the southeast.

In the same line with this series, and about one mile and a half further to the southwest, occurs another somewhat shorter belt of the altered limestone, a little beyond Lion Pond. The length throughout which the limestone has been modified, does not exceed two hundred or three hundred feet, and the width of the belt is not considerable. The locality is nevertheless an interesting one, for we find well exposed, within a tract not more than a fourth of a mile wide, first, the primary strata on the southeast, then the sandstone, F. I., next the blue limestone, F. II. passing into the sandstone, and assuming near the passage a clear reddish hue, and lastly, the belt of altered limestone in contact with a small elevated hill or dike of felspathic sienite, the cause of the altered structure of the calcareous rock. All of these stratified masses, the gneiss, the sandstone, the blue limestone, and the white crystalline belt, dip alike towards the northwest at a gentle inclination.

Graphite is here present as usual in the calcareous mass; which besides contains other minerals.

Portions of the altered rock are coarsely crystalline, though other parts of it are more minutely granular. A variety which is variegated with numerous blue shades of plumbaginous mineral, might evidently, from its susceptibility of a good polish, be employed as an ornamental marble.

Between the sienitic ridge here spoken of and another lying a short distance to the north, there occurs another smaller belt of the altered limestone, deeply buried between the primary rocks. At this spot some enthusiast in search of mineral treasures, expended at a former day no inconsiderable amount of time and labour, in excavations for silver ore in the sparry limestone.

West of the last mentioned point may be seen, by the side of Panther Pond, another still more unimportant exhibition of the altered sparry rock, not deserving of a special description.

there in mass, its materials, both the carbonate of lime and the commonly prevailing *graphite* and *condrodite*, are frequently mingled in variable proportions with the minerals of the intrusive veins. This incorporation of the altered products of the blue limestone, its *calcareous spar* and its *graphite* and *condrodite*, is much more intimate and more extensively seen in the ridges to the southeast, where the regular belt of the altered rock in contact with the igneous vein has resisted denudation.

Northeast of the locality to which the above descriptions have been principally confined, the belt of white crystalline limestone runs for a distance of between two and three miles, forming in some places a tract of considerable breadth. In some portions of the line the altering rock is a dike of *greenstone*, of a close grain and extreme toughness and density.

About two miles to the southwest of the place first mentioned, and near the road which crosses the mountain going from Hope towards Hacketstown, we cross the crystalline limestone at a point about a mile to the west of the little village of Danville, not far from the southwest extremity of the Great Meadow. At this locality the rock has assumed a somewhat unusual colour and aspect; the carbonate of lime, which chiefly constitutes the mass, being in the condition of rhombic spar, whose tint very much resembles that of ordinary reddish felspar. The presence, in some parts of the rock, of numerous small crystals of greenish *augite*, with occasional scales of *graphite* and even of dark *mica*, impart to the whole mass a very marked resemblance to certain varieties of granite, in which a pink felspar is the prevailing mineral. An inattentive glance at the rock will leave the traveller deceived as to its nature.

The igneous actions affecting the limestone, display their ordinary phenomena at intervals for several miles still further towards the southwest.

A small belt of the crystalline rock is traceable in the prolongation of the general line, occupying a spot a little to the southwest of the small lake called Green's Pond, and not far from the southern termination of Jenny Jump.

We again find it in the same range along the northwest base of Scott's Mountain, in two unimportant bands, the last which we discovered in the State. One of these occurs between the

but which contains, besides the ordinary ingredients, various other minerals, as *epidote*, *serpentine*, *indurated talc*, *compact steatite*, and *jade*. In some places the white limestone is wanting, having been evidently removed by denudation, as indicated by the rolled fragments occasionally met with in the adjoining plain. But even where it is absent, we observe the usual narrow ridge with its peculiar dike of heterogeneous mineral matter.

Towards the northeastern end of the belt, about two miles southwest of the road which leads to Long Bridge, the road parallel with the base of the mountain runs in a little narrow strip of meadow between the dike, which here shows a nearly vertical wall, and a second parallel small ridge, rising immediately on the southeast, and which is composed of the sparry limestone and altered chert, dipping at the steep inclination of 80° towards the southeast. The ridge on the northwest of the road, containing the dike, would seem to include, besides a bed of the altered limestone, having a distinct dip at this spot to the north-northeast of 70°, several magnesian rocks, as *serpentine*, *greenish jade*, *Saussurite*, and *indurated talc*.

The primary rocks in this vicinity, in the base of Jenny Jump, display marks of the most violent disruption and compression of their strata, exhibiting an unusual number of intrusive dikes and veins, in which, as in those immediately affecting the limestone, we notice a remarkable diversity of mineral composition. The constitution of the dike, or chain of dikes, directly in contact with the altered limestone, though variable, is essentially different from that of the igneous veins disturbing in a parallel line the primary strata at the base and on the side of the mountain, being characterized by a predominance of the minerals of the magnesian class.

We have evidence that the limestone at one time spread itself extensively along the base and slopes of Jenny Jump; for, not only do we find, on the sides and even summit of the mountain, scattered blocks of the stratum and its included *chert* in considerable number and size, but we observe traces of its having undergone fusion and incorporation with the materials of some of the dikes and veins before alluded to, at the southeastern foot of the mountain. Though the white sparry rock is no longer visible

there in mass, its materials, both the carbonate of lime and the commonly prevailing *graphite* and *condrodite*, are frequently mingled in variable proportions with the minerals of the intrusive veins. This incorporation of the altered products of the blue limestone, its *calcareous spar* and its *graphite* and *condrodite*, is much more intimate and more extensively seen in the ridges to the southeast, where the regular belt of the altered rock in contact with the igneous vein has resisted denudation.

Northeast of the locality to which the above descriptions have been principally confined, the belt of white crystalline limestone runs for a distance of between two and three miles, forming in some places a tract of considerable breadth. In some portions of the line the altering rock is a dike of *greenstone*, of a close grain and extreme toughness and density.

About two miles to the southwest of the place first mentioned, and near the road which crosses the mountain going from Hope towards Hacketstown, we cross the crystalline limestone at a point about a mile to the west of the little village of Danville, not far from the southwest extremity of the Great Meadow. At this locality the rock has assumed a somewhat unusual colour and aspect; the carbonate of lime, which chiefly constitutes the mass, being in the condition of rhombic spar, whose tint very much resembles that of ordinary reddish felspar. The presence, in some parts of the rock, of numerous small crystals of greenish *augite*, with occasional scales of *graphite* and even of dark *mica*, impart to the whole mass a very marked resemblance to certain varieties of granite, in which a pink felspar is the prevailing mineral. An inattentive glance at the rock will leave the traveler deceived as to its nature.

The igneous actions affecting the limestone, display their ordinary phenomena at intervals for several miles still further towards the southwest.

A small belt of the crystalline rock is traceable in the prolongation of the general line, occupying a spot a little to the southwest of the small lake called Green's Pond, and not far from the southern termination of Jenny Jump.

We again find it in the same range along the northwest base of Scott's Mountain, in two unimportant bands, the last which we discovered in the State. One of these occurs between the

little villages of Oxford and Concord, and the other still further to the southwest, near Davison's Mill, which brings us to within one mile of the Delaware river.

I have been thus full in describing the singular phenomena of induced crystallization, caused in the limestone by igneous agency, and in endeavouring to trace to their several sources the various extraneous minerals which accompany the alteration, from a persuasion of the interesting relations of the whole subject to the important doctrine of the metamorphosis of rocks.

The great thickness throughout which the limestone has undergone a most thorough crystallization from the heating agency of the dikes which traverse it, and the curious law traceable in the developement of some of the minerals, which appear in the light of segregations from elements contained in the limestone, afford unquestionably strong support to the theory, which assumes that gneiss and other primary strata have once been sedimentary rocks, converted by an extremely intense and wide spread igneous action into a universally crystalline state.

Respecting the question of the probable date at which the mineral injections occurred, which have so singularly modified the structure of the adjacent limestone, we can merely hazard some general conjectures, which rest rather upon analogies than upon a foundation of facts.

Economical Relations of F. II.

Perhaps of all the rocks in the State, the formation whose geological structure we have now described, is that which is most extensively and variously applicable to the useful purposes of life.

(*a.*) Among its several important uses, we may advert, in the first place, to its adaptation as a *building stone.* The great readiness with which it may be quarried, the facility with which it may be shaped and cut, its agreeable colour, and, above all, its strength and almost perfect indestructibility by atmospheric agents, unite to recommend it in the construction of dwellings, barns, public edifices, and the structures connected with civil engineering, such as locks, bridges, and aqueducts. Lamentable inattention, however, is frequently displayed in the choice of the

material for these purposes, varieties being selected which require an unnecessary amount of time and care to shape; and which, after an exposure of a season or two to the atmosphere, assume a rusty tint, in consequence of containing too large a quantity of oxide of iron. To avoid the former of these defects, it is only requisite to examine closely the form and texture of the freshly fractured surfaces of the rock, which should generally split with a smooth, even, somewhat conchoidal fracture, and present to the eye a very regular and close grain, with a clear, uniform, and decided tint, either of gray, or grayish-blue, or blue. To detect the presence of an injurious proportion of the oxide of iron, calculated in course of time to stain the exposed surface of the rock, one of the readiest and simplest methods is to reduce a portion to powder, moisten it with a little water, and add a little pure muriatic acid. The existence of oxide of iron will be made apparent by a brownish tinge, seen while the material is dissolving.

(*b.*) Another highly useful purpose to which this rock is often applied, is in the construction of McAdam roads. As a road-stone, to be employed where the intercourse does not require a very heavy draught, it is at once the cheapest, most readily procured, and easily broken material accessible to very extensive and important districts, not merely of New Jersey, but of the Middle States. Much judgment, it is believed, may be displayed in the selection of those kinds which will prove the toughest and most difficult to abrade under the wheels. Those possessing a subcrystalline texture, and a rough, irregular fracture, especially when they contain a certain amount of silica and oxide of iron, I have usually conceived to be the best adapted to endure attrition. A little practice with the hammer, will soon enable us to ascertain approximately, the kinds likely to prove most suitable.

(*c.*) *Marbles.*—The great calcareous formation which we have described, is characterized by several varieties which are fairly entitled to the name of ornamental *marbles*, when we consider their fineness of grain and susceptibility of a delicate polish, combined with their several soft and pleasing shades of colour.

Among the beds which pass ordinarily by the name of limestone, we meet with portions uniting the requisites of texture with the most beautiful and delicate tints; some are of a very pale-

blue approaching to *white;* others are of a *dun-colour;* while some are gray and blue marbles, delicately *mottled, veined,* and *shaded.* In the Mendham Valley, a variegated pinkish colour is associated, in a few cases, with a texture deemed sufficiently fine to admit of a good polish. The *white crystalline marbles* of the altered belts have been already spoken of. The *pure white* and granular kind, seen in many places around Franklin and Sparta, and further to the southwest, would afford, if carefully quarried and polished, a superior marble; while the clouded kind, such as we find near Long Pond, might be procured in very beautiful varieties. The presence of the pale-yellow Brucite, in some very white portions of the granular rock, would constitute a beauty rather than a defect. Other portions of this altered rock are in some places delicately arborescent.

A variegated greenish marble, susceptible of an excellent polish, occurs, connected with small injected veins of *serpentine,* near Augusta, adjacent to the anticlinal axis of the Paulinskill Valley. It has all the characters of an ornamental marble, the rock being penetrated in all directions by little veins of serpentine of a lighter and darker green, mingling with the mass of the rock so as to impart to it numerous beautiful shades. The occurrence of minute brightly yellow cubical crystals of *sulphuret of iron* in some parts of the mass, is calculated to heighten rather than impair its beauty. A change seems to have been induced in the texture of the rock by the intrusion of the serpentine, nearly effacing its original marks of stratification, and causing numerous irregular cross joints.

This creates some little difficulty in quarrying it, but if the excavation were attempted on a larger scale for the purpose of finding for this marble a regular market, the rock could be procured in larger and better shaped pieces than at present. It does not show more liability to irregularities in the quarrying, than such rocks usually exhibit.

Character of the Lime for Mortar and as a Fertilizing Agent.— The lime from different portions of Formation II. possesses various degrees of excellence for mortar.

Two principal species include nearly all the varieties of this rock, however they may differ in point of colour and aspect. The first of these is composed chiefly of carbonate of lime, the extra-

neous ingredients being *oxide of iron*, sometimes a little *oxide of manganese*, a little vegetable or animal organic matter, and water. The second kind, besides all these several constituents, contains a large proportion of carbonate of magnesia, from which it derives peculiar and important properties.

Those beds of the rock which possess, as I have already described, a clear decided tint, especially any shade of blue, and a smooth, sharp, even fracture, and close, fine grain or texture, will yield almost invariably, a pure white lime, admirably adapted for making common mortar; but which is destitute of the property of hardening under water. Some very dark varieties furnish a beautifully white and pure lime, the colouring matter consisting of bituminous substances, which are entirely consumed in the process of burning. Such limestones are apt to emit a disagreeable fœtid smell when broken or strongly rubbed.

The *magnesian limestones* constitute a very important portion of the formation before us. Until my brother, Professor William B. Rogers, of Virginia, first analyzed these rocks, which he has done extensively and systematically as they occur in that State, their existence was hardly recognised, much less their remarkable abundance. My own researches made in Pennsylvania and New Jersey, confirm the fact of the magnesian character of a large portion of this great limestone formation.

Their economical value as *hydraulic cements*, very recently ascertained to be dependent upon the presence of the magnesia, gives additional interest and importance to the developement of these extensive beds.

No certain guide can be given for recognising the magnesian varieties of the limestone, as only the eye of an experienced observer will detect those nice shades of aspect, which denote the presence of both the alkaline earths. The best general criterion, is a certain dulness in the appearance of the surface, even when freshly broken, and the absence of that fine smooth grain distinctive of the pure varieties of the limestone.

The recently discovered general fact, already alluded to, that the property of forming a *hydraulic cement* depended upon the large proportion of *carbonate of magnesia* in the limestone, was first hinted at by M. Vicat, of France, and since confirmed by an extensive series of analyses and experiments, carefully conducted

by my brother, not only upon specimens of the formation as it occurs in Virginia, but upon other limestones of New York and Kentucky, the details of which were submitted to the public in his annual report on the geological survey of Virginia for the year 1838. He there demonstrated that the *magnesia* is invariably a prominent ingredient in all the limes which readily set under water, while the other constituents, *silica*, *oxide of iron*, and *alumina*, seem not to be essential, being variable, and most usually existing in comparatively minute proportions. His researches thus far made, would indicate that in the specimens yielding an active hydraulic lime, the average proportion of the *carbonate of magnesia* to the *carbonate of lime* is about three to five.

In corroboration of these interesting and useful results, I here present several analyses of the magnesian limestones of New Jersey. After determining accurately the chemical composition of each specimen, a portion of the same mass was carefully calcined, made into cement, and left to repose under water, the progress and extent of the hardening being ascertained by an instrument, devised by a French experimenter for that purpose.

The more highly magnesian varieties proved in every instance good hydraulic cements.

Analyses.

Blue Limestone from Lafayette, Sussex county.

Description.—Colour, bluish gray; texture, close-grained and subcrystalline.

Specific gravity.—2·838 at a temperature of 56° Fahr.

Composition.—In 100 parts:

Carbonate of lime, -	53·04
Carbonate of magnesia, -	41·04
Alumina and peroxide of iron,	0·96
Insoluble matter, -	3·24
Moisture and loss, -	1·72
	100·00

Blue Limestone, Johnsonburg, Warren county.

Description.—Colour, light bluish gray; texture, slightly subcrystalline.

Specific gravity.—2·837 at a temperature of 59° Fahr.

Composition.—In 100 parts:

Carbonate of lime, -	53·52
Carbonate of magnesia, -	38·74
Alumina and peroxide of iron,	0·73
Insoluble matter, -	6.29
Moisture and loss, -	0·72
	100·00

Blue Limestone, near Anderson, Musconetcong Valley, Warren County.

Description.—Colour, dark blue; texture, very fine grained and compact; fracture slightly conchoidal.

Specific gravity.—2·847 at a temperature of 58° Fahr.

Composition.—In 100 parts:

Carbonate of lime, -	53·59
Carbonate of magnesia, -	41·58
Alumina and peroxide of iron,	1·38
Insoluble matter,	3·44
Moisture and loss,	0·01
	100·00

This is said to have been employed as a hydraulic cement with success.

Blue Limestone, south of the Paulinskill, on the road from Newton to Swartwout's Pond.

Description.—Colour, light bluish gray; texture, moderately close grained; aspect, somewhat dull and earthy.

Specific gravity.—2·832 at a temperature of 54° Fahr.

Composition.—In 100 parts:

Carbonate of lime, -	54·95
Carbonate of magnesia, -	33·99
Alumina and peroxide of iron,	2·10
Insoluble matter, -	7·45
Moisture and loss, -	1·51
	100·00

Blue Limestone, Hacketstown Valley, Warren county.

Description.—Colour, dull bluish gray; texture, moderately close grained, and slightly subcrystalline; has interspersed veins of calcareous spar.

Specific gravity.—2·831 at a temperature of 69° Fahr.

Composition.—In 100 parts:

Carbonate of lime, -	50·23
Carbonate of magnesia, -	37·13
Alumina and peroxide of iron,	0·63
Insoluble matter, -	9·93
Moisture and loss, -	2·08
	100·00

The above five analyses refer, it need hardly be said, to Formation II., which will be found, I doubt not, upon an extensive examination, to be more often magnesian than purely calcareous.

Having shown the carbonate of magnesia to be an abundant ingredient in many of the limestones, the lime of which is used among the farmers of those districts for assisting the fertility of the soil, it may be of some service to the agricultural interests of the State, to endeavour in this place to correct the generally prevailing impression, to this day widely propagated by writers, of the injurious action of magnesian lime upon the land. It is now clearly established, that a *large proportion* of the lime employed by the farmers of the southeastern counties of Pennsylvania, for a long series of years past, with such eminent benefit to the permanent fertility of their soils, is, without their being aware of it, *highly magnesian*. This is of itself enough to refute the popular prejudice upon this subject. But the analyses above given, of a number of those of New Jersey, of well known repute as to their agricultural fitness, will enable the farmers of Warren and Sussex counties in particular, to judge of the merits of this question for themselves, by uniting with the chemical results here presented, their own agricultural experience. While the evidence from experiment and trial now brought forward, goes conclusively to show, that the magnesia cannot be poisonous to the crops, agreeably to common belief, it still leaves an interesting and useful question undetermined, whether the mag-

nesia is merely *inert*, or whether, like the lime, it exerts an actively fertilizing influence upon the soil.

Nothing short of a series of agricultural experiments, judiciously planned and perseveringly conducted, aided by chemical analyses performed upon the limestones used, can settle this important economical inquiry. Alive as our farmers are becoming to the inestimable utility of calcareous manures, it must soon prove to them a matter of interest, to ascertain whether the magnesia, constituting often more than 40 per cent. in the lime which they spread, is really salutary or wholly inoperative.

The white crystalline limestone of the altered belt, especially of Sussex county, recommends itself strongly for its purity and whiteness, particularly that procured from the more perfectly rhombic variety.

It has long been made into lime near Hamburg, from whence that material has been transported over the Highlands to the towns of Patterson, Newark, &c., commanding, at times, as high a price as one dollar per bushel. This is admirably adapted for the finer kinds of masonry, by the whiteness of the cement which it yields; and it is especially fitted for making the hard finish for walls and cornice work.

In the neighbourhood of Lockwood there occurs a fine exposure of the crystalline limestone, in a belt already described. This being within about three miles of the Morris canal at Stanhope, where there is a ready transportation to Newark and other towns where lime is in demand, the business of burning the stone is beginning to invite attention. The pure rhombic semitranslucent variety, which is, to a great extent, free from magnesia, and capable of producing, when properly burned, a lime of superior excellence and whiteness, is here in great abundance.

The annexed analysis will show the composition, in 100 parts, of this limestone. Specific gravity, 2.719.

Carbonate of lime, -	95.86
Carbonate of magnesia, -	1.93
Alumina and peroxide of iron,	0.61
Insoluble matter, -	0.07
Moisture and loss, -	1.53
	100.00

It is a matter of surprise to the traveller, that, along this whole range, where the sparry limestone is so accessible, and where wood is comparatively cheap, so very little has been done by the inhabitants of the region, in manufacturing lime, either for transportation to the ready market of New York, or for home consumption, as a fertilizing agent of inestimable value to the soil. Over the whole of the Kittatinny Valley and its branches, in New Jersey, the importance of lime in agriculture has hitherto been singularly overlooked. Along the Musconetcong and German valleys, the practice of limeing has of late years become a common one; but throughout a large part of Sussex and Warren counties, where the circumstances are especially favourable for its general introduction, it remains but little attended it. The example of the southeastern counties of Pennsylvania should convince the people of New Jersey, that, upon *nearly all soils*, whether they lie immediately over the limestone rock itself, or over the slate, or belong to the sandstone and primary rocks of the hills, or to the deep loams of the river flats, the application of lime properly managed leads to sure and permanent benefit.

The magnesian character of some of the white crystalline limestone deserves attention, as it is probable that the rock will produce a *hydraulic cement*. Should the question of the comparative inertness or efficiency of magnesia in agriculture be definitely settled, it may be of importance on this account to know its composition.

By analysis, I find that the white irregularly crystalline, or somewhat granular kind, which abounds near Sparta, and between that place and Lockwood, and which is so apt to contain insulated crystals of Brucite, is decidedly magnesian, as the following results will show.

Analysis of the White Granular Limestone of Sparta, Sussex county.

Description.—White, opaque, coarsely crystalline, or saccharoidal, containing crystals of Brucite and graphite.

Composition.—In 100 parts:

Carbonate of lime, -	82.85
Carbonate of magnesia, -	15.15
Silica, Alumina, Oxide of iron,	2.00
	100.00

e Pond Marl connected with the Limestone, Formation II.

:veral places in the limestone districts of the Kittatinny we meet with a material which is identical with the *Lake* f Europe, occurring around the shores and in the beds of ıkes or ponds, and throughout some of the swampy mea- f Sussex and Warren counties. This useful deposit is only vhere the water is copiously impregnated with the carbon- ime, and hence it occurs only within, or immediately adja- , extensive limestone strata. It would seem to owe its ion, in part, to a chemical precipitation from the water; to the decay of myriads of small testaceous animals, of the usually found inhabiting calcareous waters, which, secre-) carbonate of lime to supply the material of their shells, ion after generation, accumulate it from the water in bundance. The ponds where this deposit occurs present r singular aspect, being fringed with a broad white beach.

ysis of a Fresh Water Marl, from a pond four miles from Newton.

ription.—Light ash colour; pulverulent.

osition.—In 100 parts:

Carbonate of lime, - -	90·22
Carbonate of magnesia, -	1·91
Alumina and peroxide of iron, -	0·61
Insoluble matter, - -	3·13
Organic matter, moisture, and loss,	4·13
	100·00

)nsequence of the peculiar appearance derived from this , two or three of the ponds containing it are called on the 'hite Ponds; for instance, two ponds west of Pimple Hill, ex; the more northern one being, however, incorrectly ned, as the marl is confined to the other. There is also r pond about one mile north of Marksboro', in Warren. however, are not the only depositories of this useful sub- : I enumerate the following as its localities already ascer- : White Pond, near Pimple Hill; a pond near Brighton; s' Pond, two miles south of Newton; a pond a mile and a

half northwest of Andover; the White Pond near Marksboro'; a pond at Stillwater; and some of the small ponds and marshy grounds in the neighbourhood of Hope.

The marl likewise occurs in a marshy meadow to the northeast of La Fayette, and again near Peter Merkel's, in the same range. Considering the well-tried value of this material in Europe, its importance to the agriculture of the districts which possess it, and its abundance in the two upper counties of the State, it seems truly strange that its application to the adjoining soils, should hitherto have been almost entirely overlooked by the farmers.

A material so easy of access, demanding no preparation to suit it for the soil, and unquestionably so efficient when judiciously applied, ought to be extensively used. Though much neglected until recently, this useful substance is beginning to attract attention to its valuable properties as a manure. Ample evidence is furnished of its fertilizing agency, by experience in Sussex county, even if we had not the testimony of many districts of Europe in its favour. It should be taken from the pond or low grounds where it abounds, and drawn to some convenient place, to remain in heaps, exposed to the air for several months. By this exposure it becomes dry and pulverulent, and is made to mingle with the soil more uniformly than when in its recent wet condition.

Brown or Hematitic Iron Ore.—Next to the limestone itself, the most useful mineral which belongs to this formation in New Jersey, is the brown, or *hematitic iron ore*. Though much less extensively diffused than in other parts of the same great valley, further to the southwest, this ore, from its excellent properties, is to be regarded as a valuable addition, recently discovered, to the mineral resources of the State.

The main deposit, moreover, is interesting, both in an economical and scientific light, on account of its great extent, and the singular geological circumstances under which it occurs.

As already mentioned, when describing the ranges of the altered white limestone, this large accumulation of the ore occupies the summit and slopes of a narrow ridge of the sparry rock extending parallel with the Pochuck Mountain, at a small distance from its base. The situation of the mine is about two and a half miles northeast of Hamburg, chiefly upon the western declivity of the hill. Very little rock is visible in the immediate vicinity of the

ore, which exists in the concretionary state, imbedded in a highly ferruginous clayey loam, which displays the utmost variety of colour, texture, and composition, being mottled and streaked with clays of all shades, white, yellow, red, and brown. The ore distributed irregularly throughout this mass, presents no less diversity of aspect, though it all belongs to one species, denominated *brown iron ore*. It occurs massive and cellular and sometimes fibrous, also in a mamillary and botryoidal form, and is often so hard and compact as to require blasting. The workings are generally dry. The earth in some portions of the mine gives evidence of resulting from decayed felspar and the other constituents of the adjacent gneiss rock, and contains beside much *plumbago* in a disintegrated and pulverulent state, clearly indicating that the dissolution of the crystalline limestone has been, in part at least, the cause of this large accumulation of ore.

The mineral is of excellent quality, yielding a much superior iron to that procured from the magnetic ores of the adjoining primary districts. The facility with which it may be smelted in blast furnaces, compared with the magnetic ore, is another great recommendation, and when we consider that the latter, by the usual process of reduction in bloomery forges, requires from six hundred to eight hundred bushels of charcoal to produce a ton of malleable iron, while this ore may be brought into the condition of cast iron by an expenditure of not more than two hundred bushels, costing between five and six dollars per hundred bushels, we are still further impressed with its value.

Though but five or six years in use, this ore has already become rather extensively worked, being not only smelted at a large furnace recently erected near Hamburg, but hauled over the Wallkill Mountain a distance of twelve miles to Clinton Furnace, and a still greater distance to Ryerson's Furnace, near Pompton.

Another mine of similar brown iron ore, discovered rather before that in the ridge near Pochuck, lies about a mile and three quarters east of Hamburg, above the junction of two small streams called Sand Pond and Mud Pond creeks. This deposit, already alluded to, is embraced between the primary rocks of the base of the Wallkill Mountain and a small knob of gneiss a little west of it, and lies only a short distance from the northern termination of a belt of white crystalline limestone, the disintegration of a portion

of which, once occupying this little valley, may have possibly been the source of the ore.

The present excavation is only about 140 feet long, 40 wide, and 40 deep. This deposit of ore was first brought to light, a few years since, in sinking a well.

Owing to the occurrence of much diluvial matter over the surface of the narrow valleys which embrace the altered limestone, it is highly probable that considerable bodies of the ore exist where few or no indications at the surface betray its presence. The prevalence of the mineral near the white limestone, under circumstances that imply it to have come from a rather extensive dissolution of that rock, holds out a prospect of finding it in other localities besides the above. The explorer should carefully note the signs of the removal of the altered limestone, by denudation or solution, in spots where the products of its destruction would, from the features of the ground, be most likely to remain in their usual form of a deep loamy ferruginous deposit. Such places will be the broken slopes of hills and the basins in the centre of confined valleys.

Hematitic brown iron ore occurs occasionally, though not in extensive deposits, in the limestone valleys between Schooley's and Scott's Mountains. It has been found, for example, though in rather humble quantities, very pure, between Mansfield and Anderson villages, not far from the Morris canal. It exists likewise in more abundance in connexion with the belt of limestone which forms the valley of the Delaware river, between Belvidere and Easton, having been excavated to some extent in the vicinity of Foul Rift. Much of the ore in this neighbourhood belongs to the highly valuable stalactitic variety usually denominated *pipe ore*.

Respecting the geological position of the brown or hematitic iron ore, we may give it as a general rule, admitting of no exception in New Jersey, that it abounds only in the highly ferruginous soils, which either immediately cover this limestone formation, or which lie closely adjacent to it. In Pennsylvania and some of the other States such are not its invariable relations, as several of the other rocks of the older secondary series present us with extensive deposits of the same species of ore.

Sulphate of Barytes.—West of Newton about two and a half miles, there occurs a narrow vein of the *sulphate of barytes*,

the dimensions of which, where it has been explored, appear to be too inconsiderable to render it an object of profit. It is crystalline and of a pretty pure opaque white, and has been met with in two separate spots contiguous to each other. The locality is near the disturbed anticlinal axis of the narrow belt of blue limestone, immediately northwest of the main range of slate next northwest of Newton, being removed from the principal Paulinskill tract of limestone by a narrow intermediate synclinal zone of slate.

Upon the site of one of the excavations made some years since for this mineral, a very absurd mining project was undertaken, not to procure the sulphate of barytes, which, if abundant, might repay the miner, but in the futile hope of revealing a mine of *silver*. Every informed geologist or scientific miner would pronounce at once, from all the mineral indications here present, and from the nature of this and the other rocks, that such attempts at mining for the precious metals in these strata are likely to prove wholly abortive; nevertheless a shaft sixty feet deep and at a cost of two thousand dollars has already been dug. I deem it my duty to state, that I could discover in this mine nothing that seemed to contain a trace of silver, or any thing to justify the anticipation of finding it.

The barytic mineral has become of recent years a substance of considerable demand in commerce, from the rather extensive use now made of it by the manufacturers of white lead, many of whom have been driven by the spirit of competition to mingle it in a finely levigated condition, in a greater or less proportion, with their manufactured article. This adulteration, if such it can be called, would seem not to affect materially the interests of the consumer, as the mineral appears rather to dilute than injure seriously the quality of the white lead, while the reduction in the price will compensate, or nearly so, for the somewhat increased quantity of the paint which it becomes necessary to employ.

SECTION III.

Of the Slate of the Kittatinny Valley, Formation III.

Geographical Range of the Formation.—Having adopted the ascending order in this description of the rocks of the ancient

Secondary or Appalachian System, the next stratum which presents itself, reposing immediately on the limestone, is the slate of the Kittatinny Valley. This rock, as already intimated when tracing the axes of elevation in the limestone, ranges in several long and narrow belts, the limits of which were specified while treating of their position in the synclinal troughs embraced between the upheaved zones of the limestone. Extending our present enumeration to all the several belts within the State, we have now to include, with those alluded to, the principal tract of the region which occupies the northwestern side of the Kittatinny Valley, throughout its whole length across New Jersey.

Tracing the limits of these different ranges with as much minuteness as the purposes of a general description render necessary, we shall begin, as usual, with those which lie farthest towards the southeast.

The first is that narrow belt at the Wallkill, about three miles northeast of Deckertown, which runs southwestward, passing about a mile northwest of Hamburg, and a little southeast of Harmonyvale and Lafayette. It terminates about two miles southeast of Newton in a narrow point. This low ridge of the slate is in many places not more than a fourth of a mile in width, while its length is about fourteen miles. It owes its position and form to its occupying the long *synclinal axis* included between the anticlinal axes of Pochuck and of Harmonyvale. Its beds dip from each margin at a gentle angle towards the centre of the tract.

Proceeding to the southwest, we meet two other narrow bands of slate, nearly in the prolongation of that already mentioned. One of these commences a little east of Reading's Pond, and extends, passing directly west of Greenville, almost to Sink Pond. The other lies in a parallel position at a short distance to the northwest, the two being separated by a narrow valley of the limestone, where that formation has been elevated along an anticlinal axis. Each of these little belts of slate takes the form of a low synclinal ridge.

Another somewhat larger belt, of nearly similar breadth, commences at Johnsonburg, and ranges past Hope, where it deflects a little, extending to the village of Beaver Brook, near which it

terminates. Like the other corresponding tracts, it has the form of a low narrow ridge, bounded on each side by limestone, which dips beneath it, placing it in the middle of a synclinal trough.

The next tract of slate, though in the general synclinal arrangement of its strata resembling the others, is one of far greater extent. Both its southeast and northwest margins have been already defined, when tracing the borders of the limestone, but for the sake of connexion we may briefly recapitulate them here. Beginning at the Wallkill, near the New York State line, the southeast boundary of this tract of slate runs to the southwest, passing near Deckertown, and northwest of Harmonyvale, Newton, and Johnsburg. Here it deviates more towards the west, until it passes the Free Church between Centreville and Hope. There it deflects to the south, passing Beaver Brook, and running thence in a southwest course, reaching the Delaware a little above Belvidere. The northwestern boundary, beginning on the Delaware near the mouth of the Paulinskill, pursues the southern side of that stream to Gravel Hill, near which it crosses it; recrossing a little east of White Pond, it thence extends in a northeast direction for several miles to a point about three miles north of Newton. Here it unites with the southeast margin of a narrow belt of the formation which follows the course of the Paulinskill for several miles. Beyond, where this smaller tract joins the principal one, the boundary which we are tracing proceeds to the northeast, again passing to the southeast of Augusta, and terminating near Coursenville, where the whole zone of slate southeast of the Paulinskill merges in the still more extensive one which follows the base of the Blue Mountain.

The southeast edge of this northwesternmost tract, beginning at the Delaware, about three-fourths of a mile above Columbia, pursues the northwest side of the valley of that stream to Coursenville, passing north of the little village of Walnut Valley, and northwest of Swartwout's Pond. Uniting with the former wide belt at Coursenville, the two tracts beyond that point have for their southeastern limit the boundary already traced, which passes near Harmonyvale and Deckertown to the Wallkill.

The base, or rather the southeastern flank of the Blue Mountain, constitutes the general northwestern boundary of the whole

slate formation of the valley. Near the Delaware, the common limit of the slate and the overlying sandstone of the mountain is seen at a moderate elevation above its base; but in Sussex, between Culver's Gap and the State line, the slate rises upon the eastern slope of the ridge almost to its summit, giving a fertile soil to the side of the mountain, and presenting, in a long line of cultivated farms, a landscape full of pleasing and picturesque beauty.

Composition and structure of the rock.—The ordinary character of the third formation of the Appalachian system, as it prevails in New Jersey, is that of a dark blue argillaceous slate; it is, however, very various, both as respects its colour and composition. It occurs in belts of almost every hue, black, blue, dark gray, bluish gray, dingy olive, dull brown, and even sometimes yellow.

It exhibits every grade of relative fineness and coarseness of texture, from that of the finest grained roofing slate, to that of a rough argillaceous sandstone.

At its junction with the subjacent limestone, its beds are often almost black, and more or less calcareous, while the contiguous upper layers of that rock partake in some degree of the argillaceous composition and structure of the slate. Near its upper limit, in like manner, where it and the gray sandstone of the mountain are in contact, it acquires a somewhat arenaceous texture, and in certain layers passes to a gray argillaceous sandstone.

Nearly all parts of this extensive formation, which is evidently of very great thickness, present that highly curious feature of structure denominated *cleavage*. This remarkable tendency of the mass to split into thin plates by planes of cleavage, which preserve a uniform direction and inclination over extensive tracts, independently of all variations in the texture of the rock, and of all changes in its dip, is a feature which belongs to many of the ancient slate rocks, both of the old and new continents; but in few regions can it be studied on a more extensive scale than in the Kittatinny Valley, where it is visible for a great distance on both sides of the Delaware river. While the beds of slate throughout a large portion of the northwestern belt dip towards the base of the Blue Mountains, or to the northwest, and while those of the

next great zone to the southeast, especially near the Delaware, have been disturbed by an anticlinal axis giving them both a northwestern and southeastern dip, the planes of cleavage are observed to maintain invariably a southeastern, or, more properly, a *southern* inclination, which is usually between 40° and 60° to the horizon. Their *strike*, or the line formed by their intersection with a horizontal plane, is, therefore, far from coinciding with the prevailing strike of the strata themselves. And it is not a little curious, that this law, of a nearly south-southeast direction in the dip of the cleavage surfaces, holds true, not only of the slate but of all the contiguous formations of the series, except the *coarse sandstone* and conglomerate rocks of the mountain, affecting the softer variegated shales, beds of limestone, and olive-coloured slates of the still higher rocks, which occupy a breadth of many miles to the northwest. But its vast extent is more particularly seen, when we trace the formations in their longitudinal course along the Kittatinny Valley, where we may behold the cleavage planes preserving their southeastern dip, with scarcely an interruption the whole distance, from the Hudson to the Potomac, and indeed to far more distant limits in both directions.

The theoretical discussion of the interesting problem, *the cause* of this truly curious general fact, would be out of place in a work like the present, restricted, as it is, to the description of a comparatively small tract of the extensive region over which this phenomenon prevails. But a hope is cherished, of my being able at some future day, to connect it with views concerning the elevation of our primary chain and the neighbouring axes, sustained by facts, and a train of reasoning which may afford, perhaps, a satisfactory solution of this apparently obscure enigma.

The occurrence of workable roofing slates, is connected with the presence of these cleavage planes. Hitherto they have been discovered only in the belt which ranges near the base of the Blue Mountain, having never been found of sufficient purity but in the vicinity of the Delaware river, near the Water Gap.

The largest quarry is on the west side of the river, in Pennsylvania; a smaller one, yielding both roofing and writing slates of excellent quality, lies nearly opposite, on the eastern side of the river, in New Jersey. In both of these quarries, the true dip of the rock is towards the west-northwest, at an angle of about 30°:

This is detected by the inclination of the numerous thin layers or ribbons, of a different colour from the rest of the rock, marking the sedimentary structure and the true planes of deposition. The dip of the planes denoting the cleavage is towards the south-south-east, at an average angle of 50°, except where it is affected in the Pennsylvania quarry by a small fault, which, traversing a part of the slate, not only causes a local deviation in the dip of the stratum, but an alteration in that of the cleavage also.

Several favourable circumstances of structure and position, must combine to adapt any portion of the formation to being quarried for roofing slate with success.

The rock must be of a fine uniform and compact grain, as free as possible from all crushes or contortions of the stratum, cleaving with facility into thin plates in one direction, and breaking with difficulty in every other. It should be exempt, moreover, from *sulphuret of iron*, which is often found finely disseminated in the coloured seams or ribbons, and which upon exposure to moisture, soon causes a rapid disintegration of that portion of the mass. The quarry should be situated, if possible, where a small rivulet of water may be conducted over the rock, to preserve it in a moist state, in order to render it more easily and evenly cleaved.

In splitting and trimming the slates, care is taken to reject the coloured ribbons, lest, in course of time, they should undergo decomposition.

It is somewhat curious, that while the belt of pure slate between any two of these ribbons is almost perfectly uniform in texture and quality, there often prevails a sensible difference in the respects between two adjacent belts, though only separated by a ribbon of a slightly different colour, less than an inch in thickness. It merely marks a difference in the composition of the sediment, before and after that which formed the more heterogeneous ribbons.

Inferring from the highly cleavable condition and firm grain of much of the slate of the belt at the foot of the Blue Mountain, for many miles east of the Delaware, it would seem not improbable, that a minute examination of the stratum for roofing slate, might be rewarded with success at more points than one.

Except the highly useful article just alluded to, the formation described would appear not to present us with materials of much interest, as respects their economical applications.

Of *iron ores*, this formation has been found to exhibit very few indications in New Jersey, while of other minerals either useful or curious, it would seem to be equally destitute.

Some of its less argillaceous sandstone beds appear adapted to the ordinary purposes of a building stone, but care is requisite in the selection, as too large a share of argillaceous matter leads to a dissolution of the rock by the frost.

The soil over this formation is usually rather meagre and of inferior fertility, yet it is susceptible of remarkable amelioration from the application of lime, which throughout the whole length of the Kittatinny Valley, may be procured at a distance rarely exceeding four or five miles from the remotest parts of the slate districts.

Gray Sandstone of the Kittatinny Mountain, Formation IV.

Geographical Range of the Formation.—Resting immediately upon the great slate stratum above described, with a conformable northwestern dip, there is a thick series of hard and massive gray sandstones, occasionally having the coarseness of a quartzose conglomerate. These rocks are confined to the long, narrow, and nearly straight mountain ridge, remarkable for its steep flanks and almost perfectly level summit, called the Kittatinny or Blue Mountain, which crosses the counties of Warren and Sussex from the Delaware Water Gap, to near Carpenter's Point, but which, in the form of a nearly continuous mountain, reaches from within a few miles of the Hudson, near Kingston, to Cumberland county, in Pennsylvania.

Unlike the somewhat gradual transition witnessed between the slate and its subjacent limestone, the passage from the slate, which occupies the lower half of the eastern slope of the mountain, to this overlying sandstone, is abrupt and every where well marked. Cropping out in many places in a bold and rugged escarpment along the upper part of the southeastern side, it forms the rough but level summit of the ridge, and usually about one half of its northwestern slope.

The relative position of this gray sandstone to the overlying

red sandstone and shale formation of the northwestern flank, and to the underlying slate, and the conformable dip of all these rocks towards the northwest, is well exhibited in that fine natural gorge of the mountain, the Water Gap of the Delaware. Here, the entire structure of the ridge is exposed, showing the gray sandstone rising in bold grandeur from the water's edge to the crest of the mountain, an elevation of about fourteen hundred and fifty feet. The ridge preserves this height with a remarkably straight and even summit for many miles, in both directions from the river. This levelness and perfect straightness of the mountain top, the regularity of its grand escarpment on the east, and the striking uniformity in the general dip of its strata, suggests the remarkable equality in the intensity and direction of that force from below, which uplifted from their deep bed under the waves, this ponderous mass of rocks.

Composition and Structure.—The gray sandstone formation of the Kittatinny Mountain consists of a thick series of hard white and whitish-gray siliceous rocks of various degrees of coarseness, from that of a fine-grained pure sandstone to that of a quartzose conglomerate of thickly set pebbles, averaging half an inch in diameter; these several varieties are found interposed in frequent alternations, though the fine-grained sandstones most abound in the upper half of the stratum, while the conglomerates prevail to rather greater amount in the lower division. In the vicinity of the Lehigh river, in Pennsylvania, the main deposit consists of pebbles, often of great size, which compose the lowest beds of the formation, resting in immediate contact with the subjacent slate.

From the Susquehanna river to the district of the Lehigh and Delaware, the formation would appear to augment progressively in thickness and general coarseness of composition, being only about four hundred feet thick near the first river, and almost two thousand feet at the Lehigh; but advancing from the Water Gap of the Delaware towards the Hudson, it again abates somewhat in thickness, retaining, however, its full proportion of the white quartzose conglomerates.

Upon examining the composition of the rock, it will be found to consist of rounded fragments in the condition of sand and fine gravel, derived from the primary rocks lying southeast and east

of it, and in part from the three inferior older-secondary formations of its own group, ranging parallel with it in the Kittatinny Valley. Among these materials we occasionally meet rounded pebbles of the flint or chert, characteristic of the limestone, though none of the softer carbonate of lime itself; also small flattish fragments of the directly underlying slate rocks.

These constituents, of themselves, imply that some great disturbance of the shores of the Appalachian sea must have taken place suddenly, interrupting the deposition of the slate, and giving rise to a series of new and more violent currents, sweeping into it a coarser class of materials from the neighbouring land and from the freshly risen sediments which now form the Kittatinny Valley. But on this interesting point we are not left to inferences derived merely from the nature of the rock; for towards its north-eastern termination, we find this formation, as we approach the Hudson, resting *unconformably*, with a gentle dip to the north-west, upon the upturned and contorted beds of the slate, giving unequivocal proof of the violence of the subterranean actions which attended the commencement of this extensive sandstone deposit. Whether the lower formations of the Kittatinny Valley emerged entirely above the waves at this epoch, in the tract which they now occupy in New Jersey, is a point open to doubt, though there exists strong evidence for believing, that, over some portions of their range at least, further to the northeast, in the neighbourhood of the Hudson and beyond it, they were thus uplifted. The general augmentation in the coarseness of the materials of the sandstone formation, as we advance from the Susquehanna towards the Hudson, would tend to confirm the opinion, that in this latter quarter the disturbances which ushered in this *fourth epoch* of the ancient secondary period had their greatest energy.

The gray sandstone of the Kittatinny Mountain is the only rock of the whole lower secondary group within the State, from the limestone of the eastern side of the valley to the limestone of the olive slate formation skirting the Delaware in Sussex county, which exhibits none of the oblique cleavage planes so conspicuous in Formation III. Its massive beds are traversed by joints, having the same dip and strike, and attributable, probably, to the same origin.

Its quartzose materials and coarse aggregation have probably

interfered with its assuming this structure on a minuter scale. It may be given, indeed, as an almost universal rule, applicable to the whole range of the Appalachian rocks, that wherever this cleavage prevails extensively, it shows itself in the sandstones on a scale commensurate, as to distance between the planes, with the thickness of their beds and their coarse arenaceous character. For even in these coarser strata, though the divisional surfaces are three feet and more asunder, they preserve their regularity and constancy of direction, and their parallelism to the slaty cleavage of the argillaceous parts of the series.

ORGANIC REMAINS.

The relics of organic life imbedded in this great sandstone formation are singularly few, if we except two or three interesting species of *marine vegetation*. These belong to the tribe of extinct seaweeds called *fucoides*. The principal varieties are the *fucoides Brongniartii*, and the *fucoides Alleghaniensis*. The cliffs in the middle of the gorge of the Delaware Water Gap exhibit fine specimens of the former, covering with a beautiful reticulation the faces of the white sandstone beds over many square yards of surface. The latter species abounds where the formation alternates in its upper layers with the lower beds of the overlying red sandstone. Properly considered, it is a fossil more strictly characteristic of the latter rock, being confined in this alternation of the formations chiefly to the red layers. Hitherto I have discovered but one fossil of the animal kingdom in the rock of the Kittatinny Mountain.

This is a small species of terebratula of a nearly spheroidal form, found as yet in few places, and chiefly in the uppermost beds of fine-grained white sandstone. The turbulent condition of the currents in the earlier periods of the general deposit, would seem to have interfered with the multiplication of animated races on the sandy bed of that ancient unquiet sea.

ECONOMICAL GEOLOGY.

The white and light gray sandstones of this formation seem, from their durability and the regularity of their stratification, to

be well adapted to some of the purposes of a building stone, though their great hardness, and the difficulty in shaping these rocks, must restrict their usefulness chiefly to those objects where very massive or rough structures possessing great strength are intended.

The white quartzose conglomerate of this range in New York, is used for making mill-stones, which consist each of a single block. They are principally made at Esopus, the rock being taken from that part of the Kittatinny called the Shawunkunk Mountain, where the quartzose conglomerate is in great perfection. It is reputed to be well adapted for the purpose. As strata of the very same aspect and composition occur abundantly on the northwestern flank of the mountain in various portions of its range through Sussex, little doubt can be entertained that were the means of transportation as convenient as at Esopus, this application of the conglomerate would claim attention in New Jersey.

Throughout this State the formation before us is singularly destitute of useful ores or minerals. In a high valley, a little northeast of the Delaware Water Gap, between the two ridges which here form the general summit of the mountain, a small body of very excellent hæmatitic iron ore has been found, not showing, however, any indications of an abundance.

Red Sandstone and Shale of the northwestern base of the Kittatinny Mountain, Formation V.

Geographical Range.—Immediately overlying the formation just described, and occupying the valley at the northwestern base of the same mountain, upon the flank of which it sometimes rises to a considerable elevation, occurs a thick and somewhat varied formation, consisting of red and variegated sandstones and shales.

The general range of these rocks is, of course, in a belt parallel with the mountain, from the Delaware Water Gap to Carpenter's Point, where they enter the State of New York. Between the Water Gap and Wallpack Bend they occupy the narrow zone which separates the base of the mountain from the river; but, northeast of the Bend, they follow in a rather wider

tract the valley of the Flatkill, cut off from the river by a parallel belt of fossiliferous limestone, the lower member of Formation VIII.

These red sandstone rocks appear not to reach the Hudson; but, in the opposite direction, they extend a vast distance to the southwest, where they are largely developed, as they likewise are along the southern side of Lake Ontario.

Composition and Structure.—The features of this formation are considerably less diversified where it ranges across New Jersey than where it rises to the surface in some of the other States. The particular belt which follows the base of the Kittatinny Mountain is marked, indeed, throughout its whole course, by very little variety in the composition and appearance of the rock. Its more variegated aspect is confined to the belts which lie at a considerable distance to the northwest. As it occurs in New Jersey, this rock consists, in its lower beds, of a dark-red sandstone of a very ferruginous composition and extreme hardness; and in the middle and upper divisions of the stratum, of a brownish-red shale, and a very argillaceous sandstone, which are sometimes slightly calcareous. These latter layers are occasionally divided by thin bands of a different colour, commonly greenish or yellow, but of the same composition; which, as the whole rock is much affected by cleavage, assist materially in the determination of its dip. Throughout its entire range the formation exhibits the peculiar structure resulting from cleavage; this is particularly well developed in the neighbourhood of the Delaware Water Gap; where it offers some interesting phenomena to the geological student. An anticlinal axis of considerable magnitude traverses the formation for several miles, ranging immediately northwest of the Water Gap, disturbing the rocks from their usual northwest dip, and giving to them a series of undulations, distinctly traceable by aid of the lighter-coloured bands above mentioned. Notwithstanding these irregularities, the direction of the *dip and strike* of the cleavage surfaces continues every where the same, only slightly modified in their inclination to the horizon, where the cleavage and true stratification *nearly coincide*, in which case the latter exerts some influence. The usual dip of the cleavage is to a point between south-southeast and south, conforming entirely in angle and direction to

that witnessed in the argillaceous rock on the other side of the mountain.

The only *organic remains* hitherto met with in the belt of red sandstone and shale which traverses New Jersey, are the marine vegetable relics already spoken of; the species denominated *fucoides Alleghaniensis* being by far the most usually found.

ECONOMICAL GEOLOGY.

The argillaceous composition of this rock, and the extent to which it is affected by cleavage joints, unfit it, to a great extent, for usefulness as a building stone. In other parts of its wide range, at a distance from the Kittatinny Mountain, the formation includes a highly valuable seam or bed of fossiliferous iron ore, which is becoming well known throughout the central counties of Pennsylvania and Virginia; but this valuable mineral is wholly wanting where the rock rises to the surface to form its most southeastern belt at the base of the Kittatinny, and this is the portion of it which alone crosses the State of New Jersey.

In that part of the formation which ranges between the Water Gap and Wallpack Bend, two or three spots occur where *copper ore* may be seen in small amount; but all hope of discovering in this region a valuable vein of this mineral, must prove, I conceive, entirely illusory. At an early period in the settlement of the district, two or three excavations were undertaken in search of the ore, at the western base of the Blue Mountain, near Paha quarry, but nothing was reached of sufficient value to reimburse the adventurers. The mining holes are now obstructed by rubbish, but the specimens of the ore indicate nothing to warrant a renewal of the attempt.

A few indications of copper ore, chiefly the green carbonate, amounting in reality to little more than stains upon the rock, occur in the gorge of the Water Gap, connected apparently with the lower portions of Formation V. Nothing in the geology of the Blue Mountain or its neighbouring rocks, so far as the portion of it lying within New Jersey has been investigated, suggests the occurrence of metalliferous veins of any magnitude; indeed, the structure of the whole region is adverse to the supposition, though various legends of the ores of silver and lead having

been discovered here, are yet current among those ignorant of the subject.

Fossiliferous Limestone of the Delaware, Formation VIII.

Geographical Range.—Resting conformably above the formation last described, there occurs an interesting and important rock, the uppermost of the older secondary strata embraced within the limits of the State. It is a *blue fossiliferous limestone*, occupying, if we adhere to a simple classification of the strata, a position near the bottom of the *eighth formation* of the series. Its dip is invariably towards the west-northwest, at an angle averaging about 30°.

This rock enters the State at Carpenter's Point, whence it extends in the form of a rather steep ridge, parallel with the general course of the Delaware to the Wallpack Bend, where it crosses the river into Pennsylvania. This ridge has the valley of the Flatkill at its southeastern base, for nearly its whole length, bounding which, it forms in many places a rather steep escarpment. Between its northwestern base and the river, there usually extends a narrow diluvial plain, in one or more low terraces, forming the beautiful and fertile flats of the Delaware.

The rock appears to increase in thickness as we trace it northeastward from the Wallpack Bend. In fact it only begins to develope itself as a separate member in the series of our strata, between the Wind Gap and the Delaware Water Gap in Pennsylvania. This expansion, conjoined with a gradual reduction in the angle of its dip as we advance towards Carpenter's Point, causes the stratum to occupy, in the vicinity of Milford, a considerable breadth. This is the same rock which forms the chain of the Helderberg hills, west of Albany, in New York.

Composition and Structure.—The prevailing aspect of this rock is that of a rather pure blue limestone, embracing the two leading varieties, that consisting of the carbonate of lime alone, and that in which the carbonate of magnesia also forms an important part. It has usually a fine close grain, a smooth fracture, and a clear bluish or bluish-gray colour; other portions of it, however, depart from these characters, being sometimes of an argillaceous and earthy texture, sometimes sparry or subcrystalline, and some-

times so replete in fossil, shells, and zoophytes, as to possess no distinctive uniform grain.

The following analysis will serve to show the composition of this rock, as found at the Wallpack Bend.

Specific gravity.—26·94

Composition. In 100 parts:

Carbonate of lime, -	89.52
Carbonate of magnesia, -	1.45
Alumina and peroxide of iron,	1.03
Insoluble matter, - -	7.00
Moisture and loss, - -	1.00
	100.00

Though it is not difficult, by close attention, to discern its planes of stratification, and thence to recognise its dip, yet, like all the calcareous and argillaceous strata within the State, it is extensively pervaded by the system of cleavage planes, already mentioned as traversing the rocks below it in the series. These sometimes so efface all traces of the dip, as to compel the observer to resort to a careful scrutiny of the position assumed by the shells and other flattish bodies, whose larger diameters will commonly be found in the plane of the stratification. The average inclination to the horizon of the cleavage planes is about 50°, their direction being to the south-southeast, or south.

An attention to these features of structure and stratification will prove important in all cases where quarries are to be opened in this formation.

Organic remains.—It not being consistent with the plan of the present work to offer a series of engravings of the several fossiliferous formations of the State, I must content myself with indulging the hope of doing justice to this interesting subject through the medium of a different publication.

Superficial Deposits.—A somewhat curious deposit of coarse heterogeneous diluvium, cemented into a true conglomerate by the infiltration of carbonate of lime, occurs in a bed of some extent, on the western side of the Flatkill, not far above its mouth, resting immediately under the escarpment of the limestone. The calcareous matter has acted so as to agglutinate the coarse

gravel swept to this point from the valley of the Flatkill and from the flank of the adjacent mountain.

The obvious identity as to mode of origin between many rocky conglomerates of the secondary periods, and masses such as this of relatively modern date, in which we behold unequivocal evidence of the short duration and violence of the action by which the miscellaneous debris from the adjacent rocks was hurled together, will aid us, when adverted to again, to understand the nature of the circumstances that gave rise to the patches of calcareous conglomerate which form the uppermost deposit of the middle secondary strata, immediately at the southeastern base of the Highlands.

ECONOMICAL GEOLOGY.

The purer varieties of the limestone of this formation produce, by burning, a lime in no respect inferior to that derived from Formation II., either for building purposes or for agriculture. The numerous beds of *magnesian limestone* furnish a source for *hydraulic cement*, which may, at any future day, where circumstances shall warrant it, be manufactured along the Delaware at a very small expense. It is this same rock, in its range to the northeast, which has for some years past, at Rondout, near the Hudson, yielded a superior cement at a low price, and in large amount.

Travertine occurs in two or three localities in Sussex, at the base of the ridge formed of this limestone stratum. The water percolating through the rock, carrying with it only the carbonate of lime and leaving undissolved the oxide of iron, silica, and other impurities of the stratum, must of course, in depositing its calcareous particles, produce a material of great purity. This deposit, called *travertine*, is usually in the condition of a yellowish, porous, concretionary limestone, which burns into lime with great facility, and yields a product of extreme purity and whiteness. It usually collects near the base of limestone rocks, where copious springs, highly charged with the calcareous matter of the stratum, enter moist meadows or swampy grounds. It is of two kinds, concretionary or stony, and pulverulent. The first is well adapted for making into lime, or, when procurable in sufficiently

large blocks, forms a good building stone. The latter kind is often beneficially applied to the soil, being identical, in fact, with the pond or swamp *marl* already spoken of.

The *travertin*, or *calcareous tufa*, which is another name it bears, exists in both these varieties, on the Little Flatkill, about two miles southeast of Dingman's Ferry, being deposited a few hundred yards from the base of the Limestone Hill by a small rivulet. A similar collection of this material occurs nearer to the river side, a little above the ferry; and traces of its existence, though in rather small deposits, are not unfrequently noticed along both bases of the ridge for a distance of several miles.

Subjoined is an analysis of the travertin deposit, as found near Dingman's Ferry.

Composition.—In 100 parts:

Carbonate of lime, - - -	93·53
Carbonate of magnesia, - -	0·15
Alumina and peroxide of iron, -	0·42
Insoluble matter, - - - -	4·24
Organic matter, moisture, and loss,	1·66
	100·00

The position which the limestone belt holds in relation to the valleys of the Delaware and the Flatkill, enables the farmers of this favoured region to avail themselves of its fertilizing treasures, throughout its whole range through Sussex, as it is nowhere more than two or three miles from the two cultivatable tracts which border it. But notwithstanding that the beneficial action of lime on the soils along the river, and on the more gravelly lands of the Flatkill and its adjacents hills, has been long admitted by experience, there still exists on the part of many farmers, a singular indifference to this most important agent in agriculture.

Of the Circumstances which attended the Production and Elevation of the several Appalachian Rocks above described.

To comprehend fully that succession of actions which gave to the northwestern side of New Jersey its present symmetrical

geology, would require us to go aside into some of the adjoining States, where many of the phenomena essential to the inquiry are best beheld, and to take more ample latitude in some descriptions of a speculative kind, than is compatable with the design and scope of the present work. I shall restrict myself, therefore, in this place to a concise examination of a few points only, connected with the origin and present position of the Appalachian rocks.

The previous descriptions embracing but the five lowermost members of the series and a subdivision of the eighth in the ascending order, it is necessary for the discoverer to extend his researches into the adjoining State of Pennsylvania to behold the rest of that enormous group of strata, whose elevation from the bed of what I have ventured to term the Appalachian Sea, gave to a large part of the eastern half of our continent nearly its present configuration.

He will then perceive, in the first place, two important formations, absent from the series, as it is developed in Sussex and Warren, but of great thickness and vast range in other parts of the Appalachian chain. These occupy a geological position between the top of the red shale and sandstone rocks, Formation V., and the bottom of the fossiliferous limestone of Formation VIII. The lowest of these, Formation VI., is a bluish limestone, very analogous in aspect and composition to that which ranges between the Wallpack Bend and New York. The next, Formation VII., whose true place, when all are present, is between these two limestones, is a coarse white sandstone, of very distinctive features.

Above the fossiliferous limestone of the Wallpack Bend, or lower member of Formation VIII., rest the olive and brownish slates of Formation VIII., forming a stratum of great thickness, which extends over a belt of many miles in breadth northwestward from the Delaware.

Pursuing the same ascending order, and tracing the rocks in the same northwest direction to the Coal Measures of the Wyoming basin, we meet next with the red shales and argillaceous red sandstones of Formation IX.

Overlying these are the white and gray siliceous sandstones

composing Formation X., then another series of red shales and soft argillaceous red sandstones, constituting Formation XI.; and upon these are the coarse quartzose conglomerates of Formation XII., surmounted by Formation XIII., or the anthracite coal measures. This last formation, or its equivalent, the bituminous coal measures further west, occupies the highest place in the series of our older secondary or Appalachian rocks.

The several members of this multifarious group of strata give evidence, from their mutual parallelism, to which there is but the one local exception in the unconformable contact near the Hudson between Formations III. and IV., that they are the results of one strictly continuous series of sedimentary actions.

Though the chemical agencies which precipitated the limestones, and the various currents which introduced into the bed of the same great sea the mechanically suspended materials of the land, gave place to each other in frequent alternations, or underwent, from time to time, a total change, yet do we never find those geological proofs which would indicate an interruption in this prodigious sequence of deposits. Commencing in the remote period, which also saw the accumulation of the *silurian* strata of Europe, their precipitation, unlike that of the latter, was continued, unarrested by any widely influential physical revolutions, to the close of that remarkable epoch which witnessed the exuberant vegetation of the *coal;* whereas, in many portions of Europe an interval of unascertained duration must have elapsed between the elevation of the silurian deposits from their oceanic bed, and the beginning of the new order of things which brought together the materials of the great carboniferous formation. In the region of the Appalachian rocks no pause occurred in the train of sedimentary actions by the elevation and resubmersion of any part of the vast secondary sea. We therefore find, in confirmation of the other proofs of the absence of such revolutions during the accumulation of the Appalachian strata, that the fossils, the remains of the organic races of that sea, and its shores, exhibit a gentler gradation in the changes which they have undergone as to species, comparing them in the different formations of the series, than is presented when we compare the silurian and carboniferous fossils of Europe.

The conglomerate character already stated, as belonging to certain portions of the Kittatinny limestone, would seem conclusively to imply, that perfect regularity or quiescence of action did not prevail during the second epoch of the Appalachian period. And the fact of the superposition of the sandstones of the Shawunkunk Mountain *unconformably* upon the slates of the Kittatinny Valley, near the Hudson, is an evidence of another and seemingly more extensive disturbance, terminating the third epoch. To the turbulent interval which immediately resulted and brought together the coarse siliceous materials of the fourth formation, succeeded the relatively tranquil eras, as evinced by the nature of their strata, of the fifth, sixth, seventh, eighth, and ninth rocks of the series; then followed evidently two epochs of widely diffused agitation, along the Appalachian shores, the tenth and twelfth.

The heterogeneous nature of the conglomerates visible over an immense space along the mountain chain of the middle and southern States, goes plainly to establish the extensive changes in the physical geography which were taking place, in preparation, as it would seem, of that wholly new state of the surface, which so clearly characterizes the last and most striking interval of all, the *epoch of the coal.*

It is not a little curious, as casting additional light on the occurrence of a movement of elevation in the region of the Kittatinny Valley, at the close of the third epoch, that the rounded fragments of the slate of Formation III., and of the chert of Formation II., mingled with the quartz pebbles from the primary rocks still further east, occur in considerable abundance in both of the higher conglomerates, but especially in that which composes Formation XII., encompassing all the anthracite and bituminous coal fields. These fragments of the secondary rocks suggest this inference, inasmuch as they show that part at least of the slate and limestone formations had already been lifted out of their parent waves, and that the rocky strata of the land were exposed to the denuding agency which broke and rounded them into pebbles, to form a portion of these later conglomerate deposites.

As the conformability of the Kittatinny sandstone to the slate

is presented throughout their whole great range, across New Jersey and Pennsylvania, and is only locally interrupted in New York, the inference seems just, that much of the Kittatinny Valley continued, at least to a late date in the Appalachian period, beneath the waves. But the geological phenomena of the primary chain southeast of the valley, go to show, with equal force, that from that quarter probably came the principal portion of the fragments of Formations I., II., and III. These, rounded by attrition while on their journey, now constitute an interesting part of the pebbles of Formation XII.

Respecting the precise geological dates of *all* the great anticlinal axes, the results of the enormous elevatory actions which have upheaved the Appalachian strata from out of their ancient sea and given them their present inclined positions, it would be idle to speculate in the present imperfect state of our information. But the whole evidence yet collected on the subject, manifestly leads us to this striking generalization, namely, that one great and general disturbance of the strata terminated the epoch of the coal. Comparatively sudden, and immeasurably more energetic than those that preceded it, it produced the almost simultaneous elevation of the whole Appalachian chain, and was attended by a commensurately violent denudation, from the abrupt and tremendous drainage of the ancient Appalachian sea. There arose, uplifting with them a vast belt of strata, the nearly innumerable anticlinal axes of our Appalachian rocks, inclining and folding, and breaking these into all their present irregular and contorted attitudes.

CHAPTER III.

OF THE MIDDLE SECONDARY ROCKS.—GEOLOGY OF THE COUNTRY BETWEEN THE BASE OF THE HIGHLANDS AND A LINE JOINING TRENTON AND NEW BRUNSWICK; ALSO, OF THE GREEN POND MOUNTAIN.

General Description.—In the two preceding chapters, having treated in detail the geological features of the primary and the lower secondary rocks, we propose in the next place to describe the *middle secondary strata*, embraced principally within the third and remaining district of the northern half of the State.

In general aspect and composition, this group of rocks is one of the most uniform and well marked in the country, and in detailing its characters as they are beheld in New Jersey, we shall be describing, in fact, the prevailing geological structure of the whole belt, from the Hudson to North Carolina.

The formation consists of dark reddish-brown sandstone, almost invariably argillaceous, of soft crumbly brown shales and coarse conglomerates, the latter frequently of very heterogeneous composition. The prevailing, we might say the almost invariable direction of the dip of the strata is towards the north, at angles varying from 15° to 25°. The lower beds, or those which show themselves along the southern edge of the tract, consist most frequently of rather coarse sandstones alternating with red shales, the sandstones being formed of somewhat angular fragments of quartz, felspar, and other ingredients of the neighbouring primary rocks, cemented by a paste of brown argillaceous matter. The central parts of the series consist more exclusively of brown shales and brown argillaceous sandstone, while the uppermost beds, occurring along the northwestern margin of the formation, have frequently the character of coarse conglomerates, made up of pebbles derived from a very great variety of rocks, chiefly those which occur at the base or on the sides of the adjacent primary hills of the Highlands. Where a large proportion of the pebbles are of limestone, and the cementing red earth which unites them contains an adequate quantity of the same material, the rock

possesses the character of a marble, being susceptible of a good polish, and resembling certain highly variegated breccias.

Though this conglomerate constitutes the uppermost member of the red sandstone group in various places, both in New Jersey and Pennsylvania, there are other neighbourhoods, for example, near Bainbridge, on the Susquehanna, where it would seem rather to occupy a position at the base of the series. All these rocks of the middle secondary date, of which the argillaceous red and brown sandstone is the predominant and characteristic variety, appear, from numerous geological indications, to have been produced at a period subsequent to the elevation of the lower secondary strata, including the coal deposits. They seem to have originated in a long narrow trough, which had its source as far south at least as the eastern base of the Blue Ridge in Virginia and North Carolina, and which probably opened into the ocean somewhere near the present position of the Raritan and New York bays. Their materials give evidence of having been swept into this estuary, or great ancient river, from the south and southeast, by a current producing an almost universal dip of the beds towards the northwest, a feature clearly not caused by any uplifting agency, but assumed originally at the time of their deposition, in consequence of the setting of the current from the opposite or southeastern shore.

Numerous ridges and dikes of trap, some of them many miles in length, traverse the area occupied by this formation in New Jersey. The date of their appearance at the surface was manifestly subsequent to the deposition of the red argillaceous strata through which they have burst, overflowing, while in the melted state, the adjacent beds, and greatly altering their texture, colour, and mineral aspect.

In what exact period during the secondary ages of the earth's geological history, this widely-diffused series of sedimentary strata, and their accompanying igneous rocks, originated, we are at present unable to determine with strict scientific precision, but we are not without data for a somewhat satisfactory approximation.

The organic remains hitherto discovered are extremely few, and the evidence they afford is not sufficient to establish within near limits the era to which these strata should be referred.

They consist merely of a few rather imperfect relics of one or two species of *fishes*, some indistinct impressions of *fucoides*, or other aquatic vegetation, and occasional thin bands of a *ligniform coal*, in which the fibrous structure, apparently that of the wood, is traceable. The other organic remains, particularly of the fishes, imply a date somewhere intermediate between that of the coal and that of the greensand, and indeed suggest it as probable that the deposition of these beds commenced at an early period after the elevation of the carboniferous and other strata of the Appalachian series. That they are not so recent as the *greensand* or *newer secondary* strata of the State, is proved by their passing *unconformably* beneath that group, along the whole of their common boundary, from near Trenton to the Raritan river, and that they are more modern than the coal is, I think not less conclusively shown by their reposing unconformably, and without signs of disturbance, upon the lower members of the Appalachian rocks, in districts of the country where the uptilting of these, and of the carboniferous strata at the top of the same series, has obviously been contemporaneous.

A remarkable feature in the stratification of the whole of this red sandstone belt, is the almost invariable inclination of its beds to the northwest or north, towards the base of the Highlands, where the older secondary strata are to be seen in many places with a steep southeastern dip, passing beneath these newer rocks, which therefore abut against them in the opposite direction. Had any portion of these red rocks been produced at a period *previous* to the last, and incomparably most violent disturbance, which shook the great Appalachian basin, and which originated most, if not all, of the principal axes of elevation in the Highlands and the region to the northwest, laying bare the coal and all its attendant rocks, it is extremely difficult to conceive how they should have remained unaffected in their gentle northwestern inclination.

Later, therefore, than the carboniferous rocks, and earlier than the greensand, the most appropriate title claimed by this group of strata, would seem to be that of the *middle secondary series*. Though they present an obvious analogy in general aspect and composition to the new red sandstone rocks of Europe,

and may in fact have originated somewhere about the same epoch, yet I much prefer the above designation in the present stage of geological research, because the other name* involves the notion of an identity of age, which, from the singular paucity of organic remains in the American group, may probably never be susceptible of demonstration.

The whole middle secondary series, even where we find it, as in Pennsylvania, presenting its most varied composition, is divisible strictly into not more than three separate formations, the lowermost and uppermost of which are conglomerates, while the middle one, the main body of the series, is composed of the ordinary red sandstone and red shale. In New Jersey, we find the whole properly classified to embrace but the two upper of these divisions, the red sandstone portion, and the uppermost conglomerate, usually calcareous.

Adopting, in conformity with our general plan, the ascending order, we shall therefore describe in the three following sections:

I. The red argillaceous sandstone formation.

II. The variegated calcareous conglomerates.

III. The trap rocks intruded among and overlying both of these deposites.

SECTION I.

Of the Red Argillaceous Sandstone.

Geographical Range.—The southeastern margin of the red sandstone formation coincides, from the northern State line to the mouth of Newark bay, with the eastern boundary of the State. Emerging from beneath the range of trap rocks called the Palisadoes, on the west shore of the Hudson, it skirts the river and its bay the whole distance, in fact, from Stony Point, in New York, to the outlet of Newark bay, called the Kills, or Killvan Kiehl. Between this spot and Perth Amboy, the edge of these rocks crosses Staten Island.

From Perth Amboy, we trace it along the north side of the

* Employed by Professor Hitchcock, for the corresponding rocks in the valley of the Connecticut river. See Report on the Geology of Massachusetts.

Raritan river, which it crosses nearly opposite Lawrence's brook. Its course thence is along this latter stream for several miles, until it is interrupted by a prolongation from the ridge of trap rock which passes south and east of the Sandhills. On the south of this belt of trap, the sandstone is again seen near the head of Heathcote's brook, from whence it takes an almost westerly course to Kingston. Here its margin deflects south, keeping a little to the southeast of the Raritan canal, to the head of the Shipetaukin swamp, the northwestern edge of which it pursues nearly to the junction of the Shipetaukin with the Assunpink, from whence to the Delaware river, a course of about five miles, it follows the northwest border of the Trenton belt of the primary strata.

The northwestern border of the formation, commencing at the State line, pursues for several miles the course of the Ramapo river, in contact with the primary, until it is fringed by a short narrow belt of the overlying calcareous conglomerate, east of Pompton. From this place, its route is again along the primary strata, by the base of the Pompton Mountain to Montville, where it is a second time overlaid on the north, by a small tract of conglomerate.

From Montville we follow it, abutting against the primary at the base of the Trowbridge Mountain, to Mendham Valley, where it is interrupted for a narrow space by a belt of the limestone of Formation II. of the older secondary series, which it partially overlaps on its eastern side from about a mile west of Mendham to Pepack. From this point its course is to the Lamington river, and it is for the third time covered on its northern side by the calcareous conglomerate which borders it in a nearly continuous belt, passing New Germantown, to a spot nearly north of Lebanon, on the turnpike. Curving around the base of a small hill of trap, and another of gneiss, it next skirts the edge of the tract of limestone of the south branch, where its range is nearly westward along the limestone, by Perryville and Pattonburg. In the neighbourhood of the Old Hickory Tavern, it meets the gneiss at the foot of the Musconetcong Mountain. About two miles beyond that spot, about the head of Milford run, it is once more, for the fourth time, bordered by the superior beds of the calcareous conglomerate, lying here at the foot of

the Musconetcong Mountain. Following the southern edge of this narrow belt for about six miles, it finally quits the State by crossing the Delaware river, near the mouth of Gallows run.

Composition and Structure.—While the prevailing and distinctive rocks of this formation are a dark brownish-red sandstone, and a soft and friable argillaceous red shale, it presents a considerable diversity, especially among its lower beds, both as respects its aspect and composition. In some parts of the series, we find the argillaceous matter so predominant, that certain beds assume almost the character of a homogeneous consolidated clay, of a brown or dark purple colour, in which the laminations are hardly discernable. On the other hand, the rock is not unfrequently composed mainly of sand, cohering into a true arenaceous sandstone, by a slight amount of clay, usually red, but sometimes white. In these cases it often contains a notable quantity of mica, and is then a red flaggy sandstone, easily divisible in the plane of stratification. In the inferior part of the formation, beds of rather coarse and heterogeneous sandstone passing into conglomerate, are not unusual. But the pebbles rarely make up the chief part of the mass, and the larger kinds are somewhat sparsely scattered, in the midst of what ought rather to be termed a coarse and angular sand. The materials of these beds seem to indicate a derivation from the contiguous primary rocks, southeast of the formation, consisting principally of rather angular grains of quartz and felspar, the latter most usually passing by decomposition into clay or kaolin, together with a less proportion of mica, and a little of the red argillaceous matter so predominant in the formation. We sometimes find in the coarse conglomerates, besides the abraded fragments of the primary rocks, flattish pebbles of the red shale, which give to the rock a rather mottled aspect.

An accurate conception of the diversified contents of this extensive formation will be best conveyed by a somewhat detailed description of its several portions, as they are exposed along a section transverse to the strike of the beds. I shall select the district bordering on the Delaware river, where the series is more entire and better developed than in any other tract of the State, and treat of each natural division in succession as it presents itself in the ascending order. Commencing, there-

fore, with the lower margin of the formation, about one mile northwest of Trenton, we find a well marked belt of strata occupying a breadth of about two miles, between that point and Hill's Creek, its northwestern limit. This consists of conglomeritic sandstones of the kind above referred to.

The materials of this lower set of rocks are pebbles and grains of sand of the same minerals which compose the primary strata, upon the upturned edges of which these rest. The rounded fragments are from the size of coarse sand to an inch in diameter, and comprehend grains and pebbles of quartz, some of which are of the semi-transparent, partially opalescent kind, pretty abundant in certain strata of the gneiss. Associated with the quartz there is much felspar, white or yellowish, and partially decomposed; also, a small share of mica and a considerable quantity of hornblende. Throughout some of the strata there is a greater or less proportion of hydrated oxide of iron, dispersed in minute yellow specks. The decayed condition of the felspar, and the stains from the oxide of iron, impair to some degree the value of these rocks for the purposes of architecture. The dip of the beds is to the northwest about 20°. A want of parallelism in the planes of stratification, and some minor irregularities, interfere with the value of many of the quarries in this range, by preventing that uniformity of structure which building stone, for many purposes, must have. A good display of these rocks, in all their distinctive features, is to be witnessed in Dean's Quarry, a mile and a half from Trenton, upon the feeder of the canal. The same varieties show themselves on the Delaware and Raritan Canal, about six miles northeast of Trenton, where the beds agree in all particulars with these inferior strata along the Feeder.

Overlying these more heterogeneous rocks at the bottom of the formation, there succeeds a belt of a somewhat different character, having a breadth of about two miles, from Hill's Creek to the stream at Abner Scudder's. The prevailing rock is a coarse-grained pinkish sandstone, consisting of transparent quartzose sand, with numerous white grains or specks of somewhat decomposed felspar, and small flattish pebbles or flakes of the more argillaceous kind of red sandstone. The chief ingredient in this rock

is siliceous sand, either transparent and white, or stained yellowish by oxide of iron. The predominant reddish colour of the rock is due to the minute particles and fragments of the red shale which it contains. The beds here described yield altogether the best building material upon the Delaware. The rock is pretty extensively quarried at the State Prison Quarry, Green's Quarry, and Hill's Quarry, and upon the opposite side of the river at Yardleyville. Its stratification is usually very regular, and it is easily wrought; and some of it seems capable, from its composition, of resisting decay from atmospheric sources. This and the next inferior group are discernible over a considerable range, pursuing a direction nearly parallel to the canal towards Princeton, beyond which they disappear beneath the overlapping strata of the upper secondary or greensand series, a little to the east of Stony Brook, and south of Kingston.

Between the stream at Scudder's, five miles above Trenton, and the small stream above the Alexsockin creek, near Centrebridge, the next extensive belt is embraced, occupying a breadth of many miles. The rocks of this portion of the formation are well exhibited near the Delaware, having been artificially excavated in numerous places to make room for the bed of the Feeder of the Raritan canal. They consist principally of those varieties which form the usual and predominant materials of the whole formation both in New Jersey and the adjoining States. The ordinary species is a rather fine-grained brown or red argillaceous sandstone, varying between soft argillaceous shale and hard arenaceous and micaceous sandstone.

The colour, though most usually red, is sometimes dull bluish, or greenish. Much of the rock exhibits cross joints, in great number and regularity, and gives proof of its having been somewhat consolidated by an elevated temperature, if we may judge from its compactness, its baked aspect, and the ringing sound which it returns when struck, and from the extent to which it is divided by these cross joints. With one single exception, in its whole breadth along the Delaware the *dip* is invariably to the northwest, at about the usual inclination of nearly 20°. The exception referred to, occurs between Alexsockin creek and the ridge of trap about a mile above it, where the dike has burst up through the stratified rock and thrown it out of its usual inclina-

tion, and caused it to dip to the south and southeast. This disturbance of position does not, however, prevail over perhaps more than half a mile; and it is singular enough, that adjacent to and between the three other bold ridges of trap which cross the strata nearer Trenton, no similar displacement of the prevailing dip has taken place. I may mention in this place, the same interesting fact in connection with nearly all the principal outbursts of trap rock in the State, which produce no disorder in the original attitude of the strata, though conclusive evidence will be offered presently, that the trap must have issued through the stratified rocks after their deposition. The stratified sandstone rises almost to the top of Goat Hill on its eastern slope, dark and altered in texture, but preserving its ordinary dip to the northwest.

Upon the northwest side of the large ridge of trap called Goat Hill, there have arisen changes in the mineral contents and structure of the adjacent strata which are highly curious and important when regarded in a scientific point of view. I allude to the existence in the sandstone of a profusion of nodules and crystals of *epidote*, *tourmaline*, and other minerals hardly ever found but in igneous and volcanic rocks, but caused here by the heating influence of the vast mass of trap, as it issued from the interior, in a molten state. When treating of the trap rocks of the red sandstone region generally, I shall dwell more at length upon these interesting mineralogical changes.

This broad tract of argillaceous red sandstone and shale is intersected in its range to the northeast by the valley of the Raritan, where its beds are finely exposed to observation the whole distance from Perth Amboy to Boundbrook. To the northeast of the Raritan, nearly the whole of that part of the middle secondary region included between Staten Island and the Hudson on the east and the trap ridges on the west, consists of this division of the formation. Resting upon this rather uniform portion of the series, we find near the Delaware another somewhat more varied set of strata extending between the small stream below Centrebridge and the Wickhecheoke, about two miles above its mouth. They consist of a series of alternating red sandstones and coarse yellowish conglomerates, occasionally divided by narrow beds of the softer argillaceous red shale. These conglomerates resemble closely those which occupy an inferior position

in the formation, and which appear within three miles of the gneiss at Trenton. A large portion of the pebbles, which frequently are half an inch in diameter, consist of quartz and felspar; the latter occasionally in a decomposing state. With these are mingled flatter pieces of red shale, the whole being bound together by a small amount of ferruginous matter acting as the cement. Much of this latter rock is merely a coarse sandstone, and in the vicinity of Centrebridge, and at intervals for a mile and more above, it occurs of a quality excellently fitted for architectural uses, having been fully tried in the bridges upon the upper end of the Feeder.

This rather arenaceous part of the formation, extends nearly to the mouth of the Lockatong, if we follow the bend of the river. Commencing a little above that stream, we meet with an elevated table-land, the surface of which is about four hundred feet above the Delaware. At the valley of the river this is about three miles wide, but it expands towards the northeast, until it reaches the valley of the South Branch of the Raritan. Its lower edge is traced by a line, commencing at Bull's Island, and passing west of Sergeantsville and Flemington. Here it bends to the north to follow the South Branch to within three miles of Clinton. The upper or northwestern limit is less clearly defined, as the highly indurated strata pass, by nearly insensible shades in some places, into the less altered rocks of the tract to the northwest. An approximation, however, to its boundary, will be had by drawing a line from a little below Smithsville, on the Delaware, through Pittstown, to near the south branch of the Raritan.

Throughout this area, the rock preserves a moderately uniform external character; being a highly indurated altered shale and sandstone, the prevailing colour of which is a very dark dull blue, sometimes a deep gray, and sometimes an olive-green. It has a great tendency to split into rhomboidal fragments, with a somewhat splintery fracture; and certain varieties yield, when struck, a clear ringing sound, which has procured it the name of clinkstone in the neighbourhood.*

The tract where this rock exists, goes in Hunterdon county under the name of the Swamp, owing to the wet character of the prevailing soil. Little or no true trap rock is visible in the dis-

* True clinkstone, or phonolite, is a felspar rock of the trap family, usually fissile, and is sonorous when struck; whence its name.

trict, except along the southern border, where, as for example, northwest of Flemington, it may be seen following the direction of the altered strata. It is likely that numerous dikes of trap do exist, especially next the southwestern limit of the tableland, but concealed beneath the soil, or perhaps existing as narrow injected veins, not reaching the surface of the rock. The regular stratified structure and northwestern dip of the strata seem, however, not to have been changed, even where the rock appears to have undergone the most decided alteration in all its external features from the extremely elevated heat, to which it has evidently been subjected since its original deposition. There is a frequent alternation of the highly indurated beds with others, exhibiting but little departure from the commoner features of the red shale and sandstone.

In the range of country northeast of this tract, the strata, except where intersected by some trap ridges, hereafter to be mentioned, seem to have sustained no corresponding alteration of texture and colour; nor are the changes which appear in the rock for a small distance from the trap which occurs in that region, of precisely the same nature as witnessed in the strata of the Swamp.

The next belt of the formation which we meet with in our progress northwestward, commences at the verge of the altered or indurated rocks of the *Swamp*, and extends nearly to the Nischisakawick creek.

In a part of the series the rock is a compact fine-grained, but somewhat argillaceous, red sandstone, splitting into regular flagstone layers, which render it a convenient building stone, for which purpose it would seem to be, in other respects also, well adapted. Its colour is a brighter red than that which distinguishes the set of beds that next overlie it.

Between the upper border of this more arenaceous tract, and the southern edge of the variegated calcareous conglomerate, one mile north of Milford, the predominant material is a very argillaceous sandstone, with much soft friable shale, the whole being of a deep reddish-brown colour. This extends over a width, measured along a straight line parallel with the river, of about four miles. The Nockamixon cliffs, upon the Pennsylvania side of the river, exhibit a fine display of these upper beds. The angle of dip to

the northwest is very gentle, though considerably greater than it seems to be from looking at the face of that precipitous escarpment, the line of which is not sufficiently in the direction of the dip to make the full degree of inclination apparent. The chief part of the beds in this portion of the series are apparently arenaceous enough to furnish a very good sandstone for the ordinary purposes of architecture.

In other parts of their range, these beds, lying immediately below the conglomerate, are generally of the composition exhibited near the Delaware. Near Pompton, however, where the very top only of the series is exposed, the red sandstone and shale occur in somewhat different features. In a quarry near that place, the red sandstone may be seen of its ordinary character, alternating in thin beds with a very heterogeneous fine-grained conglomerate, made up of a great variety of materials, and presenting, as it were, a miniature of the variegated conglomerate above it. These sandstones are parted by very thin layers of the soft shale, almost in the state of a compressed red clay. At the dividing surface of the harder and softer layers, may frequently be found organic impressions of a class evidently belonging to some of the older aquatic tribes of the vegetable kingdom, apparently fucoides.

Upon these sandstones there rests a thin bed of a gray siliceous slate, very schistose, though of too coarse a texture to warrant its being usefully applied. Besides the sand in its composition, there is a moderate proportion of mica. Its laminæ coincide with the planes of stratification; the thickness of the whole mass is inconderable. The variegated conglomerate of this neighbourhood rests in a conformable position upon this slate. All these rocks dip to the northwest.

Having in the foregoing sketch described the several subordinate members of the red sandstone formation, as we find them developed along the valley of the Delaware, both in their ordinary condition and in their more or less altered state as affected by the neighbouring trap, let us in the next place follow some of the more continuous of these, in their range across the State towards the New York line. In consequence of the modification of texture which some of these rocks have received, by the numerous outbursts of trap, by which the northwestern half of the

region, more particularly, has been invaded, it becomes impossible to trace with any accuracy the limits of the several subdivisions, even presuming them all to have been once continuous strata; I shall, therefore, merely attempt an account of a number of localities, referring the beds described as nearly as practicable to their respective belts, as seen along the Delaware, and in doing this shall observe the usual ascending order, proceeding from the southeastern members of the formation to the northwestern.

Advancing from the Delaware towards the northeast, the first or lowest beds, reposing on the gneiss rock near Trenton, retain their coarse heterogeneous composition until they pass beneath the marshes of the Shipetaukin creek, and the canal south and east of Princeton, beyond which they are buried by the overlapping white sands and clays of the upper secondary series. On the declivity, or low escarpment, which bounds the valley of Stony Brook, near Princeton, about a mile southeast of the town, we find, near the canal, a gray arenaceous sandstone, which appears to constitute the upper part of this division, being overlaid by the more argillaceous and reddish group of beds next north of it. The rock at this place has been quarried, and supplies an excellent building stone. The main edifice of the college, and several recently erected edifices, in Princeton, are constructed of it.

The next belt, extending on the Delaware from Hill's creek to Scudder's creek, crosses the canal near Kingston. Here, and along the southern side of the Sand Hills, it encounters the trap ridge, prolonged from Rocky Hill, its beds undergoing some interesting modifications of structure, which will be more fully described when we come to treat of the trap rocks specially, and the changes induced by them.

Viewed comprehensively, the next subdivision of the formation should embrace the entire series of argillaceous red sandstones and shales, included between these arenaceous rocks and the calcareous conglomerates which overlie the whole, for it is obvious that some of the varieties separately described as occurring near the Delaware, owe their peculiar texture to igneous actions of a merely local nature. Such is the case with the thick group of beds composing the tract called the Swamp. Other subordinate strata, like the coarse sandstones near Centrebridge, would

appear not to have a sufficiently continuous range across the State to make it necessary to carry out the subdivisions of the formation, as they were detailed when describing the rocks along the Delaware.

Convenience, however, recommends that we consider separately the wide belt of argillaceous rocks, embraced between the arenaceous ones of Scudder's creek and the still coarser ones of the vicinity of Centrebridge.

The inferior margin of this zone of strata, after passing by Princeton, is prolonged to Lawrence's brook, where it constitutes also the southeastern edge of the whole middle secondary region, being overlaid unconformably along the southern side of that stream by the lowest of the upper secondary series. Beyond the mouth of Lawrence's brook, the same rocks extend every where to the eastern boundary of the State, fringing the western shores of the Raritan, of Staten Island Sound, and of the Hudson river.

The upper or northwestern margin may be traced from the stream east of Centrebridge, past Middlebrook, on the Raritan, and thence along the eastern base of the easternmost principal ridge of trap. The occurrence, in the neighbourhood of Patterson, of a coarse siliceous sandstone and conglomerate rock resembling that near Centrebridge, and the occasional appearance of a similar material at points adjacent to the line designated, seem to mark this as a boundary not altogether conventional. Within the two limits thus traced, the almost invariable aspect of the rock is that of a brownish red shale, including beds of a more or less argillaceous and micaceous sandstone of a somewhat lighter tint, some localities of which furnish good building stone and flag-stone.

Between the Delaware and the Raritan rivers the unaltered varieties of the rocks of this belt are seldom quarried, and present but few features of either economic or scientific interest.

The altered portions, important in both these points of view, will be described somewhat in detail when allusion is made to the several ranges of trap with which they are connected along the Raritan, where, as already mentioned, occur fine opportunities for studying this portion of the formation.

At New Brunswick, the dip and structure of the red shale are

beautifully exposed on the bank of the canal for a mile above the town, exhibiting the nearly parallel planes or laminæ of deposition, dipping with extreme uniformity to the northwest, at an angle of about 15°. Some of the more argillaceous layers contain a considerable amount of the carbonate of lime in small disseminated crystals, also in the form of hollow nests, lined with crystals forming bands of two or three inches thickness and of thin seams or plates of satin spar, filling the fissures of the shale. The planes of lamination are often marked by thin bands of a light bluish-green calcareous shale, which owe their peculiar colour to the iron so copiously present in the formation, usually as a peroxide, but in these instances reduced to the condition of protoxide. These bands are erroneously supposed to contain *copper*.

Northwestward, as far as Boundbrook, the stratum retains very nearly the aspect which it exhibits near New Brunswick. The only fact of interest is the gradual declension in the angle of the dip towards the northwest. Between Boundbrook and Middlebrook the rocks are well exposed on the south side of the river by the excavations made for the canal. Here the dip exhibits an unusual direction, being towards the southeast, but at an angle not exceeding 5°. This change in the inclination of the strata is not merely local, but prevails over an area of several miles to the northwest and west, the whole way to the vicinity of Pepack in the one direction, and the junction of the north and south branches of the Raritan in the other. Tracing the dip along the Millstone river, in a succession of fine exposures from Griggstown towards its mouth, we perceive it to be to the northwest, but gradually diminishing until we approach the Raritan, where it becomes horizontal, and soon after assumes the contrary direction, as beheld in the vicinity of Middlebrook. The line of no dip or synclinal axis is traceable continuously from Boundbrook, taking a west-southwest direction through Millton, or Rogers' Mills, to Flaggtown. Along the southeastern base of the ridge of trap, which extends from the Bridgewater Copper Mine towards Pluckemin, the southeastern dip is towards the hill obliquely, indicating that it is not a result of the protrusion of the trap, which, throughout the region, has usually exerted very little influence in disturbing the direction assumed by the red sandstone formation at the time of its deposition.

An explanation of the probable cause of the unusual dip assumed by the strata in this quarter will be attempted under another head, while discussing some of the physical circumstances which attended the formation of this whole series of middle secondary deposits.

Extending our observations northeast of the Raritan, we meet with few features in the geology of this belt of the red sandstone tract deserving of a special description, until we reach the neighbourhood of Newark. The direction of the dip, wherever this can be noticed, is towards the northwest at an angle rarely exceeding 15°. Between Boundbrook and Scotch Plains, along the valley of Greenbrook, so general is the covering of diluvial matter for three or four miles east of the base of the first trap ridge, that it is impossible to ascertain whether the synclinal axis passing from Flaggtown to Boundbrook is prolonged in this direction. The existence of a regular northwestern dip in the strata between the first and second trap ridges, at points north of Plainfield and Scotch Plains, renders its continuation far to the northeast of the Raritan very improbable.

The surface of the formation is covered throughout nearly the entire distance between Rahway and Plainfield, by a deep sandy loam, imbedding occasionally loose fragments of sandstone and some rolled masses of primary rocks derived from the Highlands. A level, sandy plain, stretching for some miles in length, from northeast of Scotch Plains to southwest of Plainfield, exhibits a succession of fine farms, and several thriving villages. An abundance of excellent water is usually procured by descending about fifteen or sixteen feet into the diluvial sand and gravel.

The country included between Rahway, Elizabethtown, and Newark, on the east, and Scotch Plains and Springfield, on the west, is very similar in its general aspect, being rather level, with occasional gentle swells and undulations of the surface. The soil is a fertile reddish sandy loam, well cultivated. Boulders and loose fragments of rock are fewer on the surface here than a few miles further towards the northeast. Throughout much of this area the underlying rock is deeply covered.

Pursuing our course to the northeast, the sandstone is exposed in a quarry above the village of Jefferson, in the immediate vicinity of the trap rock, dipping to the usual quarter, the northwest,

at an angle of between 12° and 15°. The main mass of the rock in the quarry is a dull red siliceous sandstone, of a uniform grain, having numerous interspersed specks of mica.

In the neighbourhood of Newark the more arenaceous variety of the red sandstone is moderately abundant, affording much good building stone. About half a mile north of the town quarries are extensively worked, giving a good exhibition of the composition and arrangement of the strata.

The rock here is for the most part a siliceous sandstone of a dull brownish-red colour, and an even grain. It contains a little mica. Alternating with the beds of sandstone are thinner layers of red, argillaceous shale, which soon disintegrates upon exposure to the air. In some of the lower beds are thin plates of carbonaceous matter, and a minute seam of a pure ligniform coal between one and two inches in thickness. The dip of the planes of deposition in this vicinity is about 10° to the northwest. Between Newark and Paterson the rock displays little or no departure from the usual character which it preserves further to the southwest in the same belt, being the usual mixture of red shale and more or less arenaceous red sandstone. Its dip is every where the same, or northwest between 10° and 15°: no change in this respect is perceptible as we approach the trap ridge to its west. Between East and West Bloomfield villages are some quarries affording a moderately good building stone. The rock is the common red sandstone of the region divided by thin interposed bands of red shale. It displays a northwest dip, the angle being 12°. In one of the sandstone beds there is seen a thin layer of coal, of a variety approaching to lignite.

Near the Passaic Falls at Paterson, the sandstone is seen under a considerable diversity of aspect, varying from a coarse conglomerate, containing numerous pebbles of white and reddish quartz, limestone, and other rocks, to a close-grained, siliceous sandstone, moderately well adapted for building stone. There are occasional interposed layers of red shale. This conglomerate and sandstone rock bears a near resemblance to that on the Delaware below Centrebridge, and would appear to occupy a corresponding position in the general series of beds which together constitute the red sandstone formation.

To the southwest of Paterson, at the Little Falls of the

Passaic, a sandstone of a somewhat different composition and appearance occurs on both sides of the river, though in the immediate vicinity of the trap dike of the second mountain; it preserves its almost invariable dip to the northwest, which is here at an angle of from 10° to 15°. This sandstone is of a very superior quality, both for the purposes of architecture and sculpture, and the quarries which have been opened furnish blocks of almost any dimensions. One of these quarries has been conducted under the direction of Mr. Thom, the celebrated sculptor, who has found in it a material extremely well adapted to receive the admirable delineations of his chisel.

From Paterson eastward to the Hudson, and northwestward to the New York line, the formation exhibits little or no departure from its ordinary type, as respects its composition, structure, and the direction and degree of dip of its planes of stratification.

The upper or northwestern half of the red shale and sandstone formation, extending on the Delaware, between the mouth of the Lockatong and the overlying conglomerate at Spring Mills, and between the first trap ridge and the foot of the primary hills in the country north of the Raritan, is nearly identical in composition with the belt already described; the chief departure from uniformity of structure in either district arising from the changes induced by the numerous ridges and dikes of trap to be presently considered. Adhering in this place to the plan proposed of presenting a brief account of the formation in the different portions of its range, by selecting a few characteristic localities where the rocks are plainly disclosed in their prevailing features unaffected by igneous agency, let us glance at the northwestern belt of the formation beginning as before at the end next the Delaware.

To the west of the wide area of altered shales, composing the tract called the Swamp, we find a zone of ordinary red shale and argillaceous sandstone, in the prolongation of the Nockamixon rocks on the Delaware. Between Evittstown and Mount Pleasant these strata are well seen under their usual type, dipping regularly and gently to the northwest. To the southeast and east of Evittstown an arenaceous variety of the sandstone affords an excellent material for architectural uses. Approaching Baptistown, the rocks begin to manifest, by a change of colour and texture, their proximity to the trap dikes of the Swamp.

From that neighbourhood northeastward this portion of the formation presents little that is worthy of record until we reach the eastern side of the Round Valley Mountain. About a mile southwest of the White Horse Tavern, and nearly opposite the curve of the Round Valley Mountain, there occurs a rather singular ridge of considerable elevation, extending southeastward from the trap. On the southwest of this long ridge the beds of the red shale have their prevailing gentle dip to the northwest, but immediately after crossing it towards the White Horse Tavern, there is a total change in the direction of the dip, which is to the northeast, at an angle exceeding 40°; the change is sudden and strongly defined. This ridge, apparently forming the axis of dislocation, extending southeastward from the curve of the Round Valley Mountain towards the Raritan, the angle of dip in the strata gradually diminishes as we proceed north, or towards New Germantown, assuming a more *eastern* inclination, and becoming, east of the Lamington river, the *southeastern* dip already spoken of.

In the valley of the Passaic river, east and south of the trap ridge, called Long Hill, the shale and sandstone, in many places, appear finely exposed for examination. They constitute an escarpment of some height on the southeastern declivity of the hill, rising nearly half way up the steep ascent, exhibiting great regularity of stratification, and an undisturbed dip to the northwest, at an angle of 15°, directly towards the trap in the body of the hill. In several spots along the base of this ridge the shale has sustained a change of aspect from the heating action of the trap. Being soft, friable, and, when wet, of a nearly black colour, it has given origin to a mistaken notion in the neighbourhood, that these strata contain *coal*, and hence many fruitless explorations have been undertaken here in search of that mineral. In fact, it is said a company was organized, and expended $1000 in digging and boring for *coal*. A little geological knowledge would have shown the absurdity of anticipating coal any where in this red sandstone formation.

On the eastern bank of the Passaic river, at a point about a mile and a half above Chatham, where the Morris and Essex Railroad crosses the stream, the red shale has been exposed to view in a quarry, from which the building stone for the viaduct over the river was procured.

Beneath several feet of alternating bands of lead-coloured and yellowish slate, lies a very extensive bed of compact red shale, in thick and solid layers. This mass has evidently been partially acted on by the elevated temperature of the adjacent trap dike of Long Hill to its west.

It is traversed by natural joints, generally several feet asunder, extending parallel with each other from northeast to southwest, separating the whole into immense blocks and tabular masses, which are readily cleft into pieces of any desirable size for masonry. In many places the laminæ of the rock are somewhat contorted. Towards the bottom of the quarry the material acquires more of the character of a sandstone. The dip is at an angle of 15° towards the west. On the same side of the Passaic, about a mile above Chatham, near a mill, the sandstone is again exposed to view by the erosive action of a small tributary stream.

At Lindsay's Mill, three miles southwest from Madison, denudation has exposed the rock in many places. It has the aspect of a thinly laminated shale, with layers of a bluish and yellowish slate, containing cubical crystals of *sulphuret of iron*. A yellowish ferruginous sandstone is also visible in one or two spots.

The indications at this place imply, that by removing the overlying shale, a good building stone, which is much wanted in this vicinity, might be procured. The dip in some places is slightly irregular, being in certain spots horizontal, and again being directed eastward at an angle of not more than 5°.

A deep diluvial bed of sand and gravel covers the plain from Morristown to the end of the ridge of trap, which extends northward from Green Village by Spring Valley; but west of this outburst of trap the sandstone appears. In the vicinity of New Vernon the red shale is often exposed, dipping generally at about 8° to the westward. South of the last named village the shale and sandstone display their ordinary features, although they show in some places traces of alteration from their proximity to the trap. The same remarks apply to the vicinity of Basking Ridge. East from this place, and northward from Long Hill and Green Village, there is an extensive level tract called the Great Swamp, consisting chiefly of meadow, the rocks here being covered throughout by a wide deposit of diluvium.

North of Plainfield, the red shale occasionally shows itself between the first and second trap ridges. A clay is found here of which good bricks are made. In the next little valley northeast of this, and still between the first and second belts of trap rock, and north of Scotch Plains, the red shale is well exhibited along the banks of the stream, presenting a low but regular escarpment in the hill side. About the middle of these beds of shale, and running parallel with them throughout the whole face of the rock, is a thin belt of *limestone*, a material of unusual occurrence, particularly in this central portion of the formation.

It is thinly bedded, in layers varying from an inch to six inches in thickness, constituting together a bed between one and two feet from top to bottom.

On the other side of the stream, in the northern face of a deep ravine, a similar, in all probability the same, bed of limestone is exposed for a considerable space. It is more massive than at the other spot, being a solid seam between two and three feet in thickness; above it and beneath it occurs the ordinary red shale, the whole dipping to the northwest, at an inclination of about 12°. The upper beds of shale along the whole valley, are here very regular, but in the bottom of the ravine above mentioned, the trap seems to have invaded the strata, inducing considerable confusion. Besides producing much alteration in the shale and sandstone, it has in places modified the limestone, giving rise to a mass of white semi-crystallized carbonate of lime. These unusual features, so easily understood by science, have led to several fruitless mining enterprises in this neighbourhood.

On the northwestern side of the mountain, near the road from a paper-mill, there is a quarry of slaty sandstone, furnishing an excellent flag-stone. It is also used for tombstones, being both neat and durable. It exhibits signs of having been baked by an adjacent dike of trap.

Following the course of the Passaic, from Chatham to the semicircular valley enclosed by the Hook Mountain, (laid down on the map as Towakow Mountain,) we pass over a wide and nearly level tract of almost uninterrupted *diluvium*. But in the recess of the Hook Mountain, the red sandstone sometimes appears along its southeastern base.

About one-third the distance from its eastern to its western

termination, there is a quarry from which much good building stone has been procured, though the rock is rather thin bedded. Notwithstanding, that it is in almost immediate contact with the trap of the Hook Mountain, the sandstone appears in this place to have undergone very little change from igneous action, nor is the usual northwest dip disturbed.

West of the Hook Mountain, between Parcipany and Montville, and again at Montville, we find the red shale and sandstone formation retaining its prevailing aspect and direction of dip. At Montville, it is overlaid by a coarse heterogeneous conglomerate, composed of very loosely cohering fragments.

The somewhat diversified character assumed by the shale and sandstone, near its contact with the variegated calcareous conglomerate of Pompton, near Ryerson's, has already been described in sufficient detail. Beyond this last named point to the State line, these rocks are occasionally exposed, but with no peculiarities of composition or structure demanding from us any special description.

The district east of the Ramapo river, for several miles is extensively overspread with diluvial matter, imbedding numerous bowlders of primary rocks, the whole having evidently come from the elevated belt of primary hills and mountains, composing the broad chain of the Highlands lying to the west and north.

Variegated Calcareous Conglomerates.

Description and Geographical range.—This heterogeneous though well characterized rock, may be regarded as a distinct formation from the group of red shales and sandstones beneath it, being the result of a wholly different train of physical causes. It constitutes the uppermost member of the middle secondary series, overlying the red shale along its northwestern margin, not in a continuous belt, but in several insulated patches that range in one general line, near the foot of the primary hills. In almost every portion of its range, the materials of this rock are extremely heterogeneous, consisting of pebbles or water-worn masses of all sizes, from that of a man's head down to that of a small pea, belonging to most of the older formations discovered in the region. A large portion of this very motley mass is made up of variously

coloured sandstone pebbles. Sometimes there is a considerable mixture of pebbles from the primary rocks; and in certain parts of its range, the stratum consists, throughout nearly the whole thickness, of pebbles of limestone, firmly cemented by a limestone paste. Usually, the cement or imbedding paste contains a sensible proportion of the materials of the red argillaceous shale of the stratum beneath. In fact, where the Baltimore and Ohio railroad crosses this rock in Maryland, the chief part of the cement is nothing else. This admixture of red matter in the rock in New Jersey is easily explained. The harder sandstones and the limestone have retained the fragmentary state, while the soft red shale has been reduced to powder or mud, by the violent action which brought together this vast mass of water-worn materials.

A large portion of the formation in its course across New Jersey, exhibits all the characters of the rock which forms the columns of the Hall of Representatives at Washington, and which has received the name of the Potomac Marble. The most northeastern locality of this rock which occurs within the State, is on the Ramapo river, near the village of Pompton. It is traceable in all its obvious features, in a belt of more than a mile in length, passing in the immediate neighbourhood of Ryerson's. Here its actual contact with the inferior sandstone formation was detected, and the conformability of the rocks clearly ascertained. Over the red sandstone rests a bed of rather thin siliceous slate, the upper portion of which is somewhat calcareous; and immediately upon this reposes the very close conglomerate containing a pretty large share of limestone pebbles. This occurs near the Ramapo, a mile to the northeast of Ryerson's. The dip of the whole is to the west, the angle being between fifteen and twenty degrees.

The conglomerate is seen again with the same dip about half a mile to the west of this, and contiguous to a ridge of gneiss, which appears to have caused some local displacement of the neighbouring strata. This is upon the border of the plain through which the Ringwood stream passes. It seems altogether probable that the difficulty of tracing the conglomerate more extensively in this quarter arises, first, from the irregularities in the direction of the strata, caused by the intrusion of the trap; and in the next place, from the western part of the formation resting beneath

the deep covering of diluvium which forms these plains. At the spot last mentioned, the conglomerate was disclosed by some over-credulous miner in an excavation for silver ore, led astray by the occurrence of very minute crystals of yellow sulphuret of iron. The rock is nearly all limestone, and specimens which have been polished, prove exactly identical in character with the Potomac marble. The conglomerate is traceable along the side of the Ramapo river, near Ryerson's barn, where it has the same dip and general composition as elsewhere, though it is less calcareous.

The next place at which we witness unequivocal traces of the formation, is at the foot of the inclined plane, upon the Morris canal, at Montville. It there forms the abutments of a mill-dam, where it will be found to agree very strictly with the slightly calcareous variety which forms the lowest part of the stratum upon the Delaware. At Montville the pebbles are often very large, and consist principally of primary rocks and red sandstone, so that it would be useless to attempt burning it for lime, although a more calcareous layer may possibly occur nearer the top of the stratum, or which is the same thing, a little farther to the northwest, that being the direction of the dip of the stratum at this place.

Another interesting belt of this formation is that which skirts New Germantown upon its northwest, in a tract perhaps half a mile wide and several miles in length, extending nearly as far north as the Lamington river. At New Germantown it is an almost pure limestone, and is somewhat extensively used for making lime. The pebbles are of various shades of colour, blue, yellowish, and red, and much of the cementing matter is tinged red. It is susceptible of a high polish, and constitutes a beautifully variegated conglomeritic marble. The dip of the rock in this portion of its range, is somewhat various in direction, but at a uniform angle of about 20°. The usual diameter of the pebbles is about an inch, though many are much larger. They are not fully rounded, but occasionally exhibit edges and angles, though much blunted and worn, as if by attrition. The superposition of this rock to the red shale or sandstone series upon which the village of New Germantown rests, is very evidently shown in its vicinity. On the northwest side of the little valley which borders the town, we see the conglomerate; while upon the southeast

side we behold, within a few hundred feet, and dipping in the same direction and at the same angle, the northwestern edge of the red shale.

The relation of the calcareous conglomerate to the underlying stratum is well shown on the route from Pepack to New Germantown, east of the Lamington river. The rock is generally a siliceous conglomerate or coarse arenaceous sandstone, with some thin layers of shale, all dipping at a moderate angle to the west and southwest.

At New Germantown, a little north of the village, the red shale is seen dipping westward, changed to a greenish-gray colour near the brook by its vicinity to a narrow dike of trap.

At the same spot an argillaceous limestone occurs, also dipping westward and occupying a place in the strata a little lower than the red shale nearer the town. About a quarter of a mile to the northeast of the bridge over the brook, are several quarries in a field east of the road, exposing the calcareous conglomerate, which is here used for burning into lime. Some of its pebbles are very large, consisting of limestone of various colours, a small proportion only belonging to other rocks. The cement is also highly calcareous. The dip of the stratum at this place, is west 5° south, at an angle a little exceeding 20°.

Half a mile northeast from this is another quarry more recently opened, exposing a calcareous conglomerate similar to that in Ogden's quarry, next to be mentioned. The beds have a gentle dip towards the southwest.

Lying about three quarters of a mile still further to the northeast, is Ogden's quarry, at present the most extensive in the tract. The cement uniting the pebbles is at this spot generally very calcareous; it is of a reddish colour, and some portions are highly stained by the brown matter of the red shale. The aspect of the rocks is singularly diversified, owing to the variety in size, shape, and colour of the imbedded pebbles. Specimens may be obtained here susceptible of a beautiful polish, and affording an ornamental marble of considerable beauty and novelty of appearance. The dip of the beds in this neighbourhood is *eastward*, at an angle of 20°. The conglomerate is not found beyond Ogden's quarry, a high ridge to the east seeming to arrest it in that direction.

About two and a half miles to the northeast, on the Lamington

river, a limestone appears; not, however, in the form of a conglomerate, but resembling that at Pepack and Mendham, and belonging evidently to Formation II. of the older secondary series. Between the Lamington river and the valley of the Pepack, this limestone is again buried under a high ridge of the arenaceous sandstone, which in this neighbourhood underlies at a short interval the calcareous conglomerate.

Tracing the conglomerate westward, we find it next in a belt separated by a space of about half a mile from the New Germantown tract. It commences on the Rockaway creek, a little north of the road to Potterstown, and ranges near the foot of the gneiss hills, for a distance of about four miles to a point a little north of Lebanon, where it is intercepted by a low ridge of the gneiss.

In aspect and composition the rock here is very similar to that at New Germantown, being equally, if not more calcareous, and therefore well adapted for burning into lime. It has evidently been much denuded, the surface being strewed with large, irregularly-shaped blocks. The dip, where it can be noticed, is towards the northwest at a gentle angle.

As the farmers of this belt of country along the base of the gneiss hills are becoming alive to the importance of lime in agriculture, a motive is furnished them for discovering this whenever it may be found; and little doubt exists that excavations will disclose it in many spots where it is now hidden by the superincumbent soil.

Another smaller tract of this useful and curious stratum, protected from the general denudation, which has obviously removed so large a portion of it along the base of the primary hills, exhibits itself on the surface near a small stream, about two miles and a half southwest of Clinton. Apparently inferior in order of stratification is a siliceous conglomerate, met with north of the stream. South of this there occurs a red shale, exhibiting considerable local derangement of dip, inclining to the southeast at an angle of 35°.

Alternating with this, and apparently underlying it, lies a calcareous slaty rock, also considerably disturbed; the prevailing dip of which is also rather steep, and to the southeast. It contains thin layers of moderately pure limestone. On the opposite side of the stream and southward of the former beds only a few

hundred yards, is the calcareous conglomerate, having the same composition with that north of Lebanon and New Germantown. Its dip is apparently to the northwest.

Pursuing our course to the Delaware, we next meet the conglomerate in a belt of more than a mile wide, between Milford and Spring Mills, coming to the river nearly opposite Gallows run. It rests conformably upon the upper layers of the red sandstone, which it joins probably about one mile to the northwest of Milford. Dipping to the northwest, or directly towards the eastern base of the Musconetcong Mountain, its near proximity renders the conclusion certain, that it meets the strata of the hill in an unconformable position.

Upon the Delaware, the rock which immediately overlies the argillaceous red sandstone, and soft argillaceous shale, is a siliceous conglomerate of great thickness, which is finely developed along the banks of the river for the distance of a mile, crossing the strike of the beds at an acute angle. The principal part of the pebbles in this portion of the formation are from the primary rocks, being chiefly quartz. They present a great diversity of size, varying from the dimensions of a pea to huge rounded masses, weighing from sixty to one hundred pounds.

Higher up the river we meet with another conglomerate, the representative of the true calcareous variety, differing obviously in composition from that just described, from which it is probably separated by intervening beds of red shale. This upper conglomerate is a less finely cemented rock, and includes a considerable proportion of calcareous matter, both in the limestone pebbles and in the imbedding paste. The fragments are less rounded and water-worn than in the conglomerate below. Somewhat angular fragments of a bluish compact limestone are frequent in the rock, while the siliceous mass exhibits but little corrosion from atmospheric agency; this more calcareous stratum presents on its surface a loose cellular structure, showing innumerable pits and cavities, from whence the limestone pebbles have been dissolved. A little below Johnson's Ferry, the rock near the road is thus greatly weather-eaten.

This upper calcareous conglomerate rarely occurs, except in the neighbourhood of the regularly stratified limestone of Formation II., along the base of the primary hills. It is in this position

accordingly, that we find it upon the Delaware, where its beds, observing a gentle northwest dip, abut unconformably against the highly upturned strata of the older limestone, reposing with a steep southeastern dip upon the primary rocks in the flank of the Musconetcong Mountain.

The more calcareous variety of this rock, where the cementing matter is not too soft, affords a material of the highest beauty for ornamental uses; and it is a subject of surprise that so little has been done to call attention to its numerous applications. The rock is frequently so exclusively composed of materials derived from limestone, that it makes as good a lime by burning as many strata which do not possess the conglomerate structure. It has been in reference to this, its most valuable property, that I have felt especially solicitous to fix as nearly as possible the range which it pursues across the State, that farmers in the northern portions of the red sandstone district, needing lime for the improvement of their agriculture, might be induced to seek it from this formation, which, when it is sufficiently calcareous, is of course the nearest source.

The theoretical views respecting the mode of origin of these masses of calcareous and siliceous conglomerate which overlie the red sandstone formation, suggested by their various geological relations, will be presented in a subsequent section, after treating of the trap rocks and the changes induced by them.

To that part of the Geology of the middle secondary region, I now proceed.

Of the Trap Rocks, and Phenomena evincing Igneous Action.

Geographical range.—Between the Hudson and Delaware rivers, the middle secondary or red shale region is traversed in a longitudinal direction, from north-northeast to south-southwest, by a number of nearly parallel ridges and dikes of trap rock, some of which are of great length and uniformity of structure. Some of these are nearly straight over a course of many miles, others are considerably curved, and several again are of a nearly semicircular form. The height of the larger of these belts is about four hundred feet, while many have not more than half or even one-fourth of this elevation. In one class of these ridges,

the entire hill consists of no other rock than the trap, the huge weathered masses of which, covering the summit and flanks, impart an aspect of extreme ruggedness. In other instances, the predominant rock at the surface is the red shale, indurated, baked, and altered in colour, by the excessive heat that has been applied to it, while the trap either does not appear at all, or has reached the day only in a series of narrow dikes. The hills of the latter class, have a more round and swelling contour, than those consisting solely of the trap, and admit of tillage to a certain extent.

To enumerate the principal trappean belts of the region we shall commence on the northeast with that called the Closter Mountain. This long range follows the western shore of the Hudson, from the Tappan Sea to Bergen Point, presenting a bold, unbroken ridge, which overlooks the river in the lofty mural precipice of many miles' length, known as the Palisadoes. The next belts west of this are the two extensive parallel ranges usually called the First and Second Newark Mountains. They commence at the Passaic, near Paterson, and keeping east of that river, pursue a course about south-southwest almost to its source, observing a nearly straight line until they approach the Raritan, where they curve, first gently westward, and afterwards more abruptly northwestward. The more eastern of these ridges is usually single; but the westernmost, especially near its southern termination, where it takes the name of Stony Hill, is in parts of its course double or even triple. West of the Passaic and east of Pompton river, Preakness Ridge, with its spurs, which united compose a continuous belt of trap, having almost the form of a horseshoe, encircles the Preakness Valley.

Somewhat similar in shape is the next principal outburst of trap rock called the Hook Mountain (Towakow on the map), which has the form of a nearly perfect semicircle, embracing in its concave the bend of the Passaic river, called the Horse Neck.

Still further to the southwest we meet several partial exposures of the trap, in the ridges west of the Passaic, near Bottle Hill, Green Village, and New Vernon, and in the more continuous belt called Long Hill.

If we add to these the hill extending from south of Basking Ridge to Pluckemin, immediately east of Mine brook, we shall

have enumerated all the conspicuous elevations of the trap north of the Raritan river.

Between the Raritan and the Delaware we have first the Rocky Hill range, commencing, properly considered, on Lawrence's brook, east of the Sand Hills, and extending across the Millstone, north of Kingston, into Rocky Hill, which forms the other half of this belt, to its western end.

Almost in the prolongation of the Rocky Hill line of trap occur the hills between Pennington and Woodville, and upon the Delaware those called Smith's Hill and Bellmont.

Northwest of Rocky Hill lies the nearly parallel range of the Rock or Sourland Mountain, having the features of a broad table land, rather than of a rugged dike of trap, its superficial rocks being chiefly altered shales.

Nearly in a southwestern direction from the end of the Sourland Mountain, the trap, probably of the same belt, shows itself near Rocktown, ranging hence to the Delaware, where it constitutes the bold ridge known as Goat Hill.

Higher up the Delaware, above the mouth of the Alexsockin, we find another shorter belt of trap, showing itself near the river.

The last principal outbursts of the rock towards the northwest, are the Round Valley Mountain, and the dike or dikes which traverse somewhat obscurely the elevated table land styled the *Swamp*, and which are traceable from near Black's Eddy for several miles to the northeast. Several other narrower dikes exist, some of which will be mentioned hereafter.

Composition and Structure of the Trap, and its Relation to the other Rocks.

The ordinary aspect of the rock varies from that of a fine-grained, compact *basalt*, to a coarsely crystallized greenstone trap. It contains, in different localities, besides its more essential components, *hornblende*, *felspar*, *augite*, and *titaniferous oxide of iron*, various other minerals of more rare occurrence, such as *epidote*, *prehnite*, *zeolite*, *stilbite*, *analcime*, and *datholite*.

The rock to which we have here given the generic name of trap, consists in reality of several varieties, differing somewhat in composition, the more important of which it may be proper to

describe. Its essential constituent is *felspar*, which is united in some cases with *hornblende*. It then belongs to the class of rocks denominated *greenstones*. In other instances the felspar is associated with *augite*, a very common case along the Delaware; and this mixture is a true *dolerite* rock. Again we find it constituted of felspar, augite, and the titaniferous oxide of iron, a composition which entitles it to the name of *basalt*. This basalt, however, often contains hornblende, as we may behold in the rock of Goat Hill. A fourth variety, of more rare occurrence in New Jersey, is the kind called *toadstone*, an amygdaloidal trap composed of a vesicular cement or paste, usually of fine-grained, rather earthy basalt, embracing small spherical or ellipsoidal cavities, occupied by extraneous minerals. A trap rock of this character occurs in the ridge north of Scotch Plains.

The crystalline structure of these trappean rocks is no less various than their composition, presenting every gradation, from that of a homogeneous paste, in which all traces of a distinct grain disappears, to a coarsely granular aspect, in which we may plainly detect the several constituent minerals. The same ridge or broad dike frequently shows all these shades of crystallization, disclosing usually the more compact varieties near the outskirts of the belt, and the conspicuously granular kinds near its centre.

The structure of the trap is usually that of a massive or amorphous rock, destitute of any greater regularity in its divisional joints than such as occasion a prevalence of the cubical and trapezoidal form in the blocks into which it separates. But in some instances is displays an approach to the *bedded* structure, as if, while in the melted state, layer had flowed over layer in a nearly parallel arrangement. This may be seen at several localities on the Delaware. In other cases, for instance at the Little Falls of the Passaic, we find it assuming the true basaltic character, separating into regularly formed perpendicular prismatic columns. At the same locality the lower portion of the mass of trap has the *spheroidal* structure, being a confused assemblage of concentric nodules.

Almost every relation which igneous rocks ever present to the strata intersected by them, may be witnessed in these trappean belts of the red sandstone region. But the usual modes of posi-

tion are, first, where the trap reposes unconformably upon the secondary strata, as may be seen in a number of interesting exposures; and, secondly, where it intersects or traverses the strata in nearly vertical dikes, conceived, from the known volcanic nature of the rock, to exist in every trappean ridge, but only occasionally disclosed to observation.

That the trap is of posterior origin to the red sandstone formation which it overlies and intersects, is obvious, but at what precise epoch we are to suppose it to have been etruded to the surface, and whether all its numerous outbursts were contemporaneous or occurred at successive periods, are points open to discussion. After reviewing all the phenomena of igneous action in the region, we shall touch upon these interesting questions.

Throughout the whole district where the trap abounds, we notice instances of its superposition to the stratified shales and sandstones through which it has burst its way to the surface. Interesting proofs of this occur along the shore of the Hudson, at the eastern base of the Palisadoes, where several varieties of the sandstone are visible near the water's side, dipping at a gentle inclination westward and into the ridge. The same thing is well displayed in the bed of the Passaic river below the Falls at Paterson; the trap reposing over the westerly dipping beds of the sandstone, and presenting some curious evidences of its having reached this position while fluid and in a state of intense ignition.

Of the Local Features of the Trap and the Alterations induced by it on the Adjacent Strata.

I now proceed to a particular account of some of the more striking features of these injected dikes, and of the modifications they have produced in the contiguous stratified rocks. Many of these changes in the texture, contents, aspect, and properties of the neighbouring rocks, attributable to the intense heat originally imparted by the intrusive trap, are of a kind familiarly noticed in the vicinity of igneous veins and dikes; but there are some which I shall have occasion to describe, that are of a less common character, and which tend, by the views connected with them, to

corroborate some fundamental doctrines recently advanced by geologists.

The first Newark mountain is an elevated range of trap, displaying in many places south of Paterson, fine mural escarpments of considerable height, especially along its eastern side. The face of these cliffs is often remarkably smooth and regular. Near Paterson, the trap rock is seen at the Falls of the Passaic overlying the red sandstone, which displays near their contact a modification of structure not unusual in such cases.

The interesting waterfall at this spot, seventy feet in height, is caused by the dike of trap which crosses the river in the form of a fine natural dam. The entire mass of water precipitating itself over the brink of this dam, passes first into a lateral cleft or chasm in the dike, and thence descends into a deep pool or basin, which it has excavated for itself in the subjacent softer sandstone. The trap rock of the cliffs around, presents a strong tendency to the columnar structure. Within a few yards above the level of the river, beneath the Falls, we behold the junction of the igneous and the sedimentary rocks. Between the true trap rock above and the altered sandstone below, there occurs a mass, of five or six feet thickness, possessing the structure of a toadstone or amygdaloid, enclosing geodes filled with prehnite, analcime, zeolite, and several other minerals. Immediately beneath this, we discover a layer of the sandstone, a few inches in thickness, bearing all the marks of partial fusion, being filled with small vesicular cavities, as if from the extrication of steam, and looking like an overbaked mass of brick or pottery.

At a gorge in the same ridge, near Plainfield, the rock departs somewhat from its ordinary aspect, being easily splintered, rather metallic in its lustre, and containing frequent streaks or fine lines of the red oxide of copper. Near another notch in the mountain, a little north of Scotch Plains, a credulous miner seeking for the precious metals, has disclosed an interesting mass of cellular or amygdaloidal trap, of a peculiar light yellowish-green colour. In this neighbourhood minerals of the zeolite family are frequently found.

While mentioning the thin seam of limestone in the narrow valley of Greenbrook, between the first and second trap mountains, a few miles north of Scotch Plains, reference has been

already made to the changes induced by the trap of this locality, both upon the limestone and the red shale.

The next belt of the igneous rock towards the northeast worthy of especial mention in this place, is that called the Second Newark Mountain. Where this ridge crosses the Passaic river, forming the gorge of the Little Falls, the structure and relations of the rock are finely developed. A little below the Falls, the trap is seen in direct contact with the red sandstone, overlying it in a mass from twenty-five to thirty feet in thickness, and presenting a rather unusual appearance. The lower portion, about fifteen feet in thickness, resting immediately on the stratified rock, is an assemblage of irregular spheroidal balls of a somewhat concentric structure, traversed in all directions by small fissures or joints; externally these are of a rather rusty hue from atmospheric action oxidizing the iron in the rock, but when broken they show a dark, iron-gray colour, with a somewhat metalliferous aspect. The material filling the interstitial portions between the balls, is a dark-coloured, close-grained, very earthy basalt. It sometimes includes crystalline quartz of various colours; among others the amethystine and smoky varieties.

Above this confused mass of nodular concretions, the rock assumes the true basaltic structure, exhibiting regular columnar prisms, beautifully symmetrical, extending up to the superincumbent soil.

At this locality, the trap rock includes crystals of prehnite, stilite, carbonate of lime, and other minerals.

Somerville Trap Ridge and Bridgewater Copper Mine.—The next point on this first belt of trap at which we meet with any phenomena of a specially instructive nature, is in the neighbourhood of Somerville, where the ridge has curved round to assume a northwest course. In the various excavations of the old Bridgewater copper mine, we have an opportunity of beholding the action of the trap upon the rock into which it has been intruded.

At this mine we have ocular evidence that the igneous rock issued through the strata through fissures of contracted width, when compared with the base of the ridge which it constitutes.

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beyond it, reaching upwards of seven hundred feet. The rock which it chiefly traverses is the red shale, not much affected in structure by the trap which overlies it in the hill, until we approach very near the point of contact of the two materials. The refuse matter at the mouth of the gallery of the mine itself, shows that very little genuine trap was intersected in cutting this tunnel across the strata.

The copper ore, which was the object sought, was found chiefly adjacent to the slightly altered shale, or immediately before it becomes excessively changed in structure, near its contact with the trap. This interesting circumstance of the position of the ore, which embraces principally the carbonate, red oxide, and silicate of copper, is by no means confined to the locality before us, but seems to prevail in relation to all the explorations of any magnitude hitherto made for copper within the State. The theory of the origin of these ores, suggested by this and other facts, will be presented under another head, when the copper mines have been specially described. The ore, as in nearly every copper locality in the State, is connected with no true *gangue* or vein stuff, implying a genuine metalliferous lode or vein, but is diffused as if by sublimation through the altered red shale, filling or lining its minutest fissures, and presenting, therefore, a large surface of bright green ore to the eye, while the metalliferous coating is in reality extremely thin.

Deeper in the hill, there occurs a more highly altered variety of the red shale, but this is usually destitute of metalliferous matter. In external aspect and structure it resembles somewhat the trap rock, but its texture and composition show it to have been the stratified shale changed by heat. Its fracture is conchoidal, very nearly resembling that of the trap, and it has the same tendency to form numerous spherical balls.

New Brunswick.—The next locality which deserves description, belongs to a more eastern belt of trappean injections. This ridge is one and a half miles west of New Brunswick, of gentle elevation, composed principally of red shale, apparently underlaid in part by trap rock. The shale has an altered colour, and in some of the higher parts of the hill, the trap obtrudes itself at the surface in loose fragments. At one point in the immediate

vicinity of the trap, there occurs a considerable quantity of the *sulphate of baryta*, scattered in detached pieces over an area of perhaps a fourth of an acre, which is nearly barren of vegetation. Precisely the same circumstances exist in a locality of the same mineral, in Bucks county, Pennsylvania; the sulphate of baryta lying adjacent to the trap, and giving rise to a remarkably sterile soil.

In some deep borings made at New Brunswick in search of water, it is evident, from the description given of the materials which were encountered, that more than one narrow dike or perhaps *bed* of trap rock was met with, whose outcrop on the surface has not been detected.*

Rocky Hill and its Prolongation.—The next trap belt, interesting from the phenomena connected with it, is that of Rocky Hill. Commencing at its eastern termination near Lawrence's brook, we observe the shale on both sides to assume, as we approach the dike, a bluish colour, and an extremely compact structure. On the southern declivity of the hill it is of a purplish or chocolate tint, and excessively hard and tough. It is studded throughout with small spherical knots or crystalline nodules, consisting apparently of the minerals epidote and hornblende, in a state of incomplete crystallization. This belt of altered shale extends from a point about half a mile southeast of the straight turnpike to the Millstone river, which it crosses at the foot of Rocky Hill, near Kingston. The changes induced in the whole lithoid character and structure of the shale, by the intruded igneous rock, are very finely exhibited along the canal, at both the northern and southern bases of the Rocky Hill dike, evincing a curious gradation in the crystalline action, as we approach the trap.

Near the southern base of the ridge, the red argillaceous sandstone displays the series of changes already noticed, its colour becoming deepened, and dark crystalline knots or kernels abound-

* I may here mention as adding another locality to the numerous ones already observed, both in Europe and this country, showing the increase of the earth's temperature as we descend, that in one of these artesian wells, the water derived from a depth of 175 feet being 52° Fahr., upon reaching a depth of 275 to 300 feet, its temperature was 54° Fahr. This last is exactly the permanent temperature of a fine natural spring, which issues from the side of a hill about a mile southeast of the town.

ing in it; we then come to the true trap, which at the river is not wide. Immediately upon the northern side of the trap, the sandstone rock re-appears with its usual dip to the northwest, but presenting some remarkable modifications. These may be seen opposite the toll-house, at the village of Rocky Hill, upon the canal, in a quarry one hundred feet to the north of the trap rock. The inclination of the strata being not more than 15°, the lower beds in the quarry cannot be fifty feet remote from the subjacent trap. They are filled to such a degree with various crystalline matters, and show therefore so much inequality of composition and hardness, as to be unfit for building stone. As we descend in this quarry, the rock departs from its character of a sandstone, though at a certain depth the change of texture is precisely that which is desirable in a material ordinarily too easily acted on by the weather. About one hundred feet from the trap, the rock has the condition of a very close-grained, compact, and reddish, or purplish sandstone, of a somewhat argillaceous texture, while it is full of dark spheroidal kernels or nodules, of a radiated structure, of the dimensions of a pea or less. The nature of the mineral is rather obscure, from the absence of all definite crystalline character. This stratum is a very durable rock, and is extracted in regular masses, furnishing a building stone which is in considerable request. In the middle of this stratum, there is a thin bed, four feet wide, which seems originally to have been a sandstone containing much felspar. It is full of small irregular cavities, the sides of which are studded with a black mineral, crystallized in regular prisms. This is schorl, regularly and perfectly developed. Numerous fissures or joints in the rock are occupied with the same black mineral, which is always highly crystallized. The rock of this bed is rejected as a building stone. Near the top of the thick stratum, of which this is but a narrow layer, the rock acquires a less altered aspect, being redder, softer, and having less of the jaspery texture, but containing kernels of pure epidote, well developed. This variety extends from where it first shows itself, which is from the trap, about one hundred and fifty feet in the thickness of the stratum, to a distance of a fourth of a mile, where it is well exposed, being excavated at another quarry. It gradually and regularly acquires the ordinary unaltered features of the red sandstone; but is even in the second

quarry remarkable for the distinctness and size of the green spheroidal masses of epidote. The degree of baking which it seems to have received even at this distance from the trap, has given it a closeness of texture which fits it finely for purposes requiring a durable building stone. Near the same quarry, the rock contains a narrow band of nearly pure epidote, about an inch and a half thick. Beyond this second quarry, towards Griggstown, the rock soon assumes its usual soft slaty texture and deep red colour.

The zone of altered shale, having the structure above described at the Millstone river, extends particularly along the northern flank and base of Rocky Hill, to its western termination, rising high on the slope of the ridge, whose southern crest alone contains the trap.

North of Princeton the southern belt of the altered rock lies in a lower ridge, parallel with the ridge of trap, but separated a little from it, the intervening depression having resulted from the comparatively easy disintegration of the highly altered rock lying directly in contact with the trap. When we trace this belt of discoloured shale westward, we find it disappearing before we quite reach the termination of the prominent portion of Rocky Hill, whose actual termination is, however, much beyond the point indicated on the map. It forms, in fact, a continuous though irregular chain with the trap hills east of Herbertstown.

Near the head of Jacob's creek, at the abrupt termination of one of these trap hills, there is an old mine, where excavations to some extent have been made in search of copper ore, the rubbish discharged from the diggings, showing some traces of that metal.

The same series of nearly continuous dikes extends to the Delaware, forming two conspicuous elevations near the river called Smith's Hill and Belle Mount. In this western portion of the belt the trap has produced effects on the shale and sandstone similar to those seen along Rocky Hill. Upon Moore's creek the strata are much altered, having a dark bluish or purple colour, and being excessively indurated. Their nearly black hue, when wet, has led to the notion that these shales are the dark carbonaceous slates of a coal formation.

In the hill called Belle Mount the trap rock is well exposed, having been excavated in making the feeder of the Raritan canal.

It possesses less of the basaltic character than belongs to much of the trap in the Newark ranges. It is of a gray colour, rather coarse texture, and consists of a large proportion of felspar, united with augite, and is therefore a true *dolerite* or augitic trap. Some portions contain hornblende instead of the augite, being in these cases the rock called greenstone trap. These two varieties are distinctive of nearly all the belts of this rock in this neighbourhood, including the important one of Goat Hill.

Sourland Mountain.—The next zone of trap and altered rock which claims our attention is that of the Sourland Mountain and its prolongation, Goat Hill. This lies northwest of the belt just described. Viewing the general topographical features of the Sourland Mountain, and the wide plain of red shale and sandstone around its base, from any part of the Somerville trap ridge distant several miles, we are led to some interesting reflections regarding the small degree of violence which has accompanied the protrusion of the trappean rocks of this region generally. Standing on the large rubbish banks of the old Bridgewater copper mine, where we are elevated scarcely one hundred feet above the general surface of the wide level tract of red sandstone spreading to the south, southwest, and west, we overlook the country for a great distance, and behold the Sourland Hill rising like a broad solitary island from the smooth surface of the extended plain. The very features of the scene are enough to indicate the absence of any great convulsive disturbance of the strata during the outpouring of the trap, which seems to have made its way to the surface through a series of long and narrow fissures, produced by the mere gaping asunder of the rocks, and not, as in some regions, by enormous vertical disruptions and irregular uplifting movements, imparting invariably a broken or undulating contour to the scene.

In the Sourland Mountain the trap rock is confined chiefly to its broad rounded summit, forming the axis of the hill; while, from this position to beyond its base, reposes, on each side, in undisturbed and regular stratification, a thick belt of the indurated and baked shale. On the northwestern flank of the mountain, towards Flaggtown, the rock in some places shows striking evidence of the intensity of the igneous action, for it has all the aspect of the fused slag or cinder of a furnace. Portions of it

are excessively hard and tough. At the base, near the northern termination of the hill, the shale still manifests a great degree of induration; it is of a blue colour and compact grain, but retains its slaty structure sufficiently to fit it excellently for flagstones, for which it is quarried. The condition of things in and around the Sourland Mountain is well seen by crossing it northward from the little village of Hopewell, near its southeastern base. Immediately north of Hopewell we pass over a ridge of little elevation, at the base of which is a light gray arenaceous sandstone, easily disintegrated, containing both the micaceous and brown oxides of iron in considerable abundance. The summit and northern declivity of this low ridge consist of blue shales somewhat indurated. Crossing a narrow valley to the southeastern foot of the main Sourland Mountain, we find its entire slope composed of the shale in a highly altered state, being blue, compact, and greatly indurated. It is excessively tough, difficult to fracture, and produces a clear ringing sound when struck. The loose masses often exhibit externally a peculiar glazed aspect, analogous to that upon the surface of some kinds of slag. These altered strata extend to the highest parts of the mountain. Crossing a slightly depressed belt, the trap rock next displays itself, and continues to the northwestern declivity, where it gives place again to the altered rocks composing the other flank. The whole mountain is thus formed of a series of nearly parallel elevations, with more or less considerable intervening depressions, or valleys, which are by no means regular, the single axis of trap rock occupying a nearly central position.

In the southwest prolongation nearly of the Sourland Mountain we find the same or rather another almost continuous and parallel dike, which passes a little south of Rocktown, and thence to the Delaware, making there the axis of Goat Hill. This elevation ranges about half a mile southeast of Lambertsville, and crosses the Delaware in an oblique direction, appearing on the Pennsylvania side below New Hope, where it displays some interesting phenomena. Along the northwestern base of this ridge, on both sides of the river, the strata dip as usual, but are affected in a striking manner in their structure and composition for at least a fourth of a mile from the trap. In the quarry northeast of Lambertsville, we discover the commencement of the change. There the red

sandstone, varying but little from its ordinary colour and being only rather more compact, contains a multitude of the large spheroidal nodules of pure green *epidote*, many of which are at least an inch in diameter. They seem not to be distributed promiscuously through the rock, but to be arranged somewhat in layers, parallel to the planes of the strata, though they are often several inches asunder. Two or three hundred feet nearer to the trap, we find the rock darker and harder, and the number of nodules greatly augmented, though they are generally of much smaller size. The common colour of the rock is here a very dull purplish blue, and that of the included nodules a dull black or a deep blue. They are of all sizes, from minute specks to the dimensions of a large hazle-nut, and possess every shade of distinctness contrasted with the material enclosing them. They seem to consist of some imperfectly formed mineral, apparently tourmaline in a semi-crystalline state. These spherical nodules or specks, are oftentimes surrounded by a crust or coating, of another material, usually nearly white; and I have remarked that the more obviously formed this crust appears, the more crystalline or fully developed is the interior kernel, which, at this spot, seems to approximate in its features to black schorl or tourmaline. A few hundred feet nearer to the trap, or almost at its base, the rock presents a still different aspect, being of a dark gray hue, and somewhat coarse-grained. It seems to have been a sandstone, containing little or no clay, as it has nothing at all of the baked jaspery texture of that previously described, which has plainly been either a shale or a very argillaceous sandstone. This gray rock is speckled with innumerable small crystals of very regularly formed *tourmalines*, some of which are more than half an inch in diameter. Upon the opposite side of the river, below New Hope, we meet with very nearly the same order of things, except that the rock containing the completely formed tourmalines is absent.

In one thin layer of the altered red argillaceous rock on the Pennsylvania side, the mass, which is of a pink hue, contains, blended with the crystallized *epidote*, some minute but perfectly formed crystals of a mineral, apparently *idocrase*, of a beautiful wine colour.

The altered belt here described, ranges northeastward from

the river for several miles, being continuous, in fact, with that already spoken of, which forms the northwestern flank and base of the Sourland Mountain. About a mile southeast of Mount Airy, the blue and purple shale contains an abundance of epidote in oblate spheroidal concretions of very regular shape. The average breadth of the belt is very considerable, amounting at least to a quarter of a mile.

West of Ringoes the shale in some places exhibits a considerable degree of change from its proximity to a bold dike of trap, which shows itself in a hill above the mouth of the Alexsockin creek. In crystalline structure this trap departs even more widely from the fine-grained basaltic variety seen in the hills near the Passaic, than does that of Goat Hill and Belle Mount, lower down the Delaware. It is coarsely granular and crystalline, consisting chiefly of a yellowish-white felspar, traversed by bladed or elongated tabular crystals of green hornblende of considerable size. Much of this rock bears indeed a closer resemblance to some varieties of sienite than to ordinary trap rock, exhibiting the justness of that generalization which makes the trappean family of rocks to include those sienites which are composed of the two minerals, felspar and hornblende. Between this belt of trap and the Alexsockin creek we find a disturbance in the direction of the dip, being the only irregularity of this kind of any magnitude in the whole red sandstone region, which is referable to the protrusive action of the igneous rock. On the southeastern side of the dike the strata of shale and sandstone are in some places much contorted and broken, but their prevailing dip is towards the southeast, or directly opposite to the usual quarter. This contrary order of the dip throughout the district along the Raritan and its north branch, I attribute to the peculiar direction taken by the currents which precipitated these sediments in this portion of the basin, and not to any upheaving force.

I have already when describing the several zones of the red shale and sandstone formation along the Delaware, mentioned the altered aspect of the strata over the wide tract called the "Swamp," the general limits of which were at the same time defined. With the exception of some occasional exhibitions of the trap rock, particularly in the vicinity of the southeastern margin

of that table land, the only material generally visible upon its surface, is the highly indurated and altered shale; the igneous matter itself having apparently in but few instances reached the day. Along the Delaware, however, about two miles above the mouth of the Lockatong, and nearly opposite the mouth of the Tohickon, near Black's Eddy, the trap appears on both sides of the river in a somewhat massive dike. On neither side of the Delaware does the trap appear at the surface on the top of the ridge or table land; and would never have been exposed, but for the denudation which excavated the deep channel through the rocks, by which the river now flows. The existence of the trap rock under these circumstances, lends confirmation to the opinion already implied, that the induration of the strata in many of the broad belts described, is the result in part of the heat propagated from masses of igneous rock which have never reached the surface.

Regarding this conclusion as almost demonstrable from the phenomena, does not analogy furnish us ground for the interesting doctrine, which attributes the crystalline structure of gneiss and other stratified rocks of the primary class, to the modifying influence of subjacent bodies of granitic, and other igneous matter intensely heated, acting upon sandstones, slates, and similar sedimentary strata?

Reviewing the several facts presented in the previous description of the principal belts of altered shale and sandstone, we find many of them of a kind calculated to add weight to this hypothesis.

In the great thickness of the zone of strata throughout which such remarkable changes have been induced in the texture, and even the molecular structure of the rock, by the heated trap, we have evidence of the magnitude of that cause, which when exerted in far greater intensity and universality upon the sedimentary deposits of the earlier periods of our planet, may have been fully adequate to produce that more entire change to general crystallization, which the metamorphic theory assumes. A curious and important proof that the modifications in the strata described, have resulted wholly from the high temperature of the molten trap, is to be found in the circumstance that all the indications of alteration or an approach to a semifusion of the mass, augment

regularly as we approach the dike. The crystalline nuclei, first extremely minute and faintly marked, become progressively larger and better defined, assuming when within a certain, though still considerable distance, all the characters of a fully developed mineral, possessing in some instances the structure of a perfectly regular isolated crystal. As this gradual segregation of certain specific mineral combinations increases, we notice a progressive obliteration of all the ordinary features of the rock.

Another highly interesting point is the intimate connexion, chemically, in every instance, between the composition of the stratum acted on, and the *species* of mineral secreted. Thus in all the principal localities of the *epidote*, we find the red shale containing by analysis all the constituents essential to that mineral, even the *lime*. Moreover, the red sandstone, so usually destitute of lime, is singularly enough the stratum in which the tourmaline, a mineral not holding any lime, abounds.

Where the rock has been a calcareous and very argillaceous red shale, the mineral produced has *invariably* been *epidote*, the ingredients of which are silica, alumina, lime, oxide of iron, and a little manganese, the five prevailing constituents of the red shale. On the other hand, where the rock has been originally a somewhat more arenaceous compound, such as usually goes by the name of argillaceous red sandstone, a triple mixture of alumina, silica, and peroxide of iron, there we find, in place of epidote, a profusion of black tourmalines, the composition of which, as analyzed by Kloproth, is 40 alumina, 35 silica, and 22 oxide of iron.

There are several other imperfectly crystalline minerals sometimes associated with the above, but I have not yet found time to investigate their composition and probable origin.

A careful examination of the altered rocks near the trap would, I doubt not, result in much useful information of a strictly practical kind, in reference especially to a right selection of stone for purposes of architecture. I conceive that the very best varieties of building rock in this region of the State, will be found in the indurated strata, contiguous to the ridges of trap, where the baking process has obliterated the slaty cleavage, and destroyed that soft friable texture which usually renders so large a portion of

the red sandstone of the district of no value. As this section of the country is not well supplied with building stone capable of withstanding the weather, the hint that durable varieties abound near the trap ridges, may prove of service. From what has been said, it will be seen that the most probable position for the better kinds, is neither too near the trap nor too remote from it, but is indicated by the amount of *baking*, which the rock appears to have undergone. This should not be too great, lest the rock be very hard and difficult to cleave into regular blocks; nor yet too little, as it will be then soft enough to be operated on by the frost. When a rather compact and extremely durable kind is sought, I would suggest that it will usually occur within one or two hundred feet of the trap, and may be known by a bluish or dull purple colour, and by a multitude of dim round spots, the commencement, as it were, of the crystalline nodules. On the other hand, when a rock of rather softer variety, but cleaveable into larger blocks, is desired, then I would propose the beds rather more remote from the trap, where the stone retains a pretty bright red colour, and contains large, fully formed nodules of green epidote.

It is not asserted that these altered strata will always appear bordering the ridges of trap; but I find them in frequency far greater than might be expected, and their importance therefore, is considerable. By following the base of a range of trap, though we may not at once meet with any rock of that exact degree of induration which we seek, we cannot pursue the search far in the longitudinal direction without falling upon a locality where all the requisite varieties present themselves. Much aid will be derived from inspecting the spots and nodules upon the fragments scattered over the surface of the soil.

OF THE COPPER ORES OF THE RED SANDSTONE REGION.

The ores of copper, especially the carbonate, red oxide, and blue sulphuret, exist in many places in the red sandstone region, though hitherto they have never been procured in abundance. Their position in every case would appear to be contiguous to dikes of trap; the present seems therefore the appropriate place in which to describe them.

The particular manner in which these ores occur, gives to the inquiry concerning them, some degree of interest both as respects the question of their origin, and the probability or not of a lucrative return for the expense of mining them. Several vigorous and persevering attempts have been made at successive times, to open mines of copper in this region, but invariably without success; and it becomes an important point to trace, if practicable, the cause of the general failure, and to ascertain in fact, whether it is not mainly referable to an actual deficiency in the amount of ore, and to its diffused state through the rock. As it is desirable that the information collected should have a practical and salutary bearing upon future mining enterprises in the district, much capital having been already absurdly wasted, I shall submit such details as have been collected, believing that the conclusions they suggest, if not positively demonstrable, are highly probable.

The principal points where mining operations have been undertaken at different times, are near Belleville, Griggstown, Brunswick, Woodbridge, Greenbrook, Somerville, and Flemington. For details concerning the early history of the mines at Brunswick, Belleville, and Somerville, I refer the reader to Gordon's Gazetteer of the State; at the same time expressing my belief, that far too favourable an impression is conveyed in that work of the metallic riches of those localities. With the exception of the Flemington Mine, which has lately been worked to some extent, and which is a more recent enterprise, these several works are all at present in such a state of decay, as to make it impossible to ascertain *by direct inspection*, the mode in which the ore occurs. My information upon this head, has been derived from examining the masses of ore and rubbish near the mines, and especially from the testimony of persons familiar with the works while they were in operation. Every thing that I have witnessed or collected in regard to it, has led me to the opinion, that the ore does not exist, in any instance, in the shape of a *true vein;* in fact, we have no evidence that a regular copper *vein*, properly so called, has hitherto been met with any where in the formations of the State.

By a true vein is meant "the mineral contents of a vertical

or inclined fissure nearly straight, and of indefinite length and depth." Such veins have usually a well-defined line or plane of separation between their contents and the rock on each side, which is named the *wall* of the vein. Now the chief peculiarity in the copper ores of the region before us is, that they occur, not in regular sheets of mixed metalliferous and mineral matter traversing the rock, but in irregularly ramifying and intersecting strings and bunches, in which the masses of ore are not mingled with the usual foreign materials of metallic veins, but blended with the adjacent red sandstone or shale, which is in a more or less *altered* state. The nature of these accumulations of metalliferous matter will be best understood, however, from a description of the position of the ore at two or three of the principal mines.

In the Schuyler Mine, near Belleville, in Essex, the principal body of the ore is stated to be imbedded in a stratum of sandstone, twenty or thirty feet in thickness, and to dip about 12° from the horizon, rather by steps than regularly. It has been worked two hundred and twelve feet below the surface, and one hundred and fifty feet horizontally from the shaft. The chief ores are sulphuret and carbonate of copper, and they occur almost invariably blended with portions of the indurated red sandstone. Judging from the latter fact and the gentle dip of the mass, which appears to be about that of the neighbouring strata, it is pretty obvious that it has but little claim to the character of a true vein, though it is not asserted that the quantity of ore in this mine may not be considerable. It would seem as if a particular band of the rock had been injected with the metalliferous matter, not filling a cleft or fissure, but dispersed and as it were dissipated by sublimation through the substance of the sandstone. There is no trap exposed on the surface any where in the immediate district of the Schuyler Mine.

At the Falls of the Passaic, near Paterson, traces of copper, in the form chiefly of the *green carbonate*, occur near the foot of the high cliff of trap rock, on the north side of the river, immediately at the base of the Falls. A fruitless excavation was formerly made at this spot, in quest of a regular vein. Huge perpendicular rents or chasms divide the trap, of unknown depth, and in a

direction nearly coincident with that of the ridge. It is into one of these great clefts that the waters of the Passaic precipitate themselves at the Falls.

In the red sandstone between East and West Bloomfield, green *carbonate of copper* is occasionally seen, but always in the form of a very thin film or crust, filling the minute seams and divisional joints of the rock, and never but in very inconsiderable quantity.

At several points in the neighbourhood of New Brunswick, ores of copper have been found; and prior to the revolutionary war, an extensive and costly attempt was made to establish a mine here, but without success. The red shale is in many places coated by the *blue* and *green carbonates* of the metal, in the form nearly of a thin pellicle. In a few instances the metal occurs in the pure state, soft and malleable, in the shape of a thin plate, injected into the body of the rock, rarely more than the twentieth of an inch in thickness. In every such case, the contiguous rock is more or less indurated, as if by heat; and in immediate contact with the vein of metal, its ordinary brownish-red colour is changed to a light-gray for the thickness of a third of an inch or so.

The Franklin Copper Mine, near Griggstown, in Somerset county, is situated on the western declivity of a hill, whose summit is occupied by trap rock, but up the side of which the shale rises to a considerable height. It is in this shale, which is considerably altered by the trap, that the copper ore has been found. The mine is in a dilapidated condition, and no longer accessible. Judging from the character of the materials brought out from the mine, and from the testimony of those who were familiar with it when open, the excavation runs for some distance horizontally through an altered shale of a dark purple colour, which becomes afterwards paler and more siliceous. The ore occurs diffused through this altered shale. Occasionally it has the aspect of existing in very narrow short strings, or little veins of injection, being in such cases mixed with carbonate of lime, felspar, hornblende, and other minerals, constituting what approximates to a true metalliferous gangue. The best ore found here is a soft *blue sulphuret*, associated always with carbonate of lime; but the principal species is the usual carbonate of copper and the *red oxide*, mingled through the altered shale, which abounds in little geodes or

crystalline nodules of epidote and black tourmaline, sometimes beautifully crystallized. The principal shaft is said to have been one hundred feet deep; and the mine was drained by a long adit which commences near the base of the hill, not far from the canal. A considerable sum has been expended without success, in opening this mine.

Interpreting all the appearances connected with the nature and the mode of distribution of the ore, it would seem to be so diffused throughout the altered shale, as to preclude its being ever profitably wrought.

At the base of the trap ridge north of Somerville, occurs the Bridgewater Copper Mine, once worked to some extent, but with a serious waste of capital. Several facts respecting the position of the ore in the midst of the altered shale, at some little distance from the dike of trap, have been already mentioned. It was found here principally in the *moderately* altered rock, near to which it is excessively baked by proximity to the igneous rock. The ore is pronounced to have been very rich, consisting of a considerable proportion of massive red oxide of copper. There was also found some *native copper*. The chief variety of ore, however, was the usual *green carbonate*, mingled occasionally with *green phosphate*, and some of the *green silicate of copper*.

This mine has been for a number of years closed up. Judging from the character of the rubbish outside of the mine, which gives a tolerably correct conception of the mode in which the ore occurs, we infer that it is here accompanied by very little true gangue or vein stuff, being sometimes in the form of thin partial injections, but much more frequently existing in a disseminated state among the altered shale and sandstone.

The Flemington Copper Mine, the only one recently wrought to any extent, being open to inspection, gives an opportunity of ascertaining accurately the usual mode of position of the ore. In this mine the appearances are almost conclusive, as regards the *absence of a true vein*, and corroborate strongly the opinion already advanced, that the chief portion of the ore has penetrated the minute crevices of the impregnated rock, rather by a species of sublimation, than by intrusion or injection in the fluid state.

There seems to be a belt of metalliferous rock of very variable

breadth, sometimes twenty or thirty feet wide, which preserves a nearly north and south direction for several hundred feet. What the total length of this may be no one pretends to know, but two miles due south from where it is exposed in the present Flemington Mine, there are strong indications of a belt of precisely similar character. In the Flemington Mine, the ore, which is a mixture chiefly of *gray sulphate* and *carbonate of copper*, exists intimately blended or incorporated with the semi-indurated and altered sandstone, and parts of the mass have therefore somewhat the aspect of a conglomerate of re-cemented fragments, the metalliferous part acting as the cement. Though usually minutely disseminated, it occurs occasionally in lumps of great purity and considerable size. The line of rock containing the ore has no definite separation from the unaltered red shale outside of it, and it is therefore not always easy to judge of the precise space which it occupies. The ore in this mine is of good quality, and so far as I have been able to ascertain, the dimensions of the band containing it, are such as to admit of the existence of a large mine here, should the proportion of metallic matter in the rock prove profitable. The mine seems to have been very judiciously worked; cuttings being made across the ore in a series of east and west alleys to ascertain its extent and position. But while mining is of all arts the most precarious, it is especially so where the metalliferous deposit does not occur under the shape of a regular or true vein or lode. The doubts which some entertain regarding the final success of this and other copper mines in the State, proceed chiefly from the views entertained regarding the manner in which the copper ore is diffused.

The Nechanic Mine lies apparently on the metalliferous belt of rock above spoken of. The ore occurs under circumstances very similar to those at the Flemington Mine. It is not at present productive.

From the excellent quality of the ore of this belt, it is to be regretted that a regular vein of some extent cannot be discovered, the disseminated condition in which the ore exists, rendering all mining operations very expensive, and limiting the supply of ore. These mines are all near a narrow dike of trap of scarcely perceptible elevation, which runs southward from the main ridge of trap and altered rock, northwest of Flemington, and extends a

considerable distance to the south. The adjacent strata are in most places considerably altered, and in some spots coated with flakes of the green carbonate of copper.

Recurring to what we have adduced respecting the copper ores of the State, it will be seen that they do not occur under circumstances to make the adventurous miner sanguine in pursuing to a costly issue, the indications of this metal which so frequently meet us throughout the red sandstone region. Numerous cases exist in other countries, it is true, where rich mines have been wrought in masses of ore that were not genuine veins, nevertheless, when the deposites are like those common in the copper region of New Jersey, mining becomes peculiarly precarious. I have been thus explicit upon this subject, from a persuasion, that one main advantage to be anticipated from a rightly conducted geological survey, is the aid which it is capable of affording to enterprise, by stimulating every branch of wholesome industry, and checking rash and visionary undertakings. It should furnish a faithful statement of what every district possesses, and when necessary of what it does *not* possess. The one is as needful as the other, if our motive be to give the industry of the community a right direction. It may depress, and it cannot strengthen the spirit of useful enterprise, to permit capital to be misapplied to purposes that, when pursued, lead to loss and disappointment.

When we contemplate the singular degree of uniformity which attends the copper ores of the State, their strict resemblance in point of composition, and the *identity* of the geological relations under which they are found, we are strongly impressed with the persuasion, that they all owe their production to one epoch, and to one generally-operating cause. Finding them in almost every case adjacent to igneous dikes, but not in contact with them, we are led at once to the inference that they entered the crevices of the somewhat crushed shales at the time of the outpouring of the molten trap, and that hence, like it, their presence at the surface is the consequence of an intense heat. The remarkable manner in which the carbonate of copper is diffused among the minutest fissures of the shale, its great *relative* abundance, and the well known property of its ready sublimation, together with the curious circumstance that both it and the other ores are rarely in im-

mediate contiguity to the trap, but among the *moderately altered less heated rocks* at a little distance, all go to indicate that a considerable proportion at least of the metalliferous matter, especially the *carbonate*, entered the strata in a gaseous or *volatile* condition, and not that of igneous fusion. This latter was more probably the state in which the metallic copper, such as occurs near New Brunswick, and perhaps some of the less volatile ores of the mine at Griggstown, were injected.

In reference to the above speculation, it should be recollected that the mass of the trap rock itself is not unfrequently seen to contain both metallic copper, and its ores.

ECONOMIC GEOLOGY OF THE RED SANDSTONE REGION.

Several subjects have been already discussed, which from their obviously practical importance, are entitled to a place in the economic geology of the red sandstone region, but it was deemed more expedient to introduce them in immediate connection with the descriptive details which respectively suggested them.

Thus, in the general description given of the several members of the red shale and sandstone formation, mention was made in every instance of the degree of adaption to useful purposes, such as those of architecture, statuary, paving, &c. of each particular belt of rock examined. A similar allusion was also made to the uses of the calcareous conglomerate, its fitness for burning into lime and for cutting as an ornamental marble being both alluded to. Care was taken to point out the precise position and dimensions of any thin beds of limestone found interstratified with the red shale or sandstone, and suggestions offered concerning the most suitable situations in which to seek for good and durable building materials among the altered rocks contiguous to the belts of trap. In like manner, in treating of the copper ores of the formation, whatever was of a practical bearing was fully considered.

I proceed to mention one or two other subjects of a somewhat desultory nature, not yet adverted to, which appear to come appropriately under this head.

Peat.—In the meadows and low boggy grounds about Springfield, and also near Connecticut Farms, occur large quantities of

excellent *peat* or *turf*. It is rather extensively dug, and employed in the neighbourhood as fuel. According to the statement given, a cord of it properly prepared is as productive of heat as a cord of good oak wood. The mode of preparing it is, to cut it into regular quadrangular masses about two feet in length, with a base four or five inches square. These pieces are carefully dried and sold by the cord like wood.

Back water on the Passaic, caused by the trap dike at the Little Falls.—The Passaic and Pompton rivers, for many miles above the Little Falls, are sluggish and half stagnant streams bordered in most places by extensive meadows and marshes, which are subject to frequent inundations, deemed prejudicial to the health of the neighbouring country. This want of current is manifestly produced by the bold dike of trap rock which intercepts the stream at the Little Falls, forming a sort of natural dam, that backs the water for a great distance along the level country above. The mere removal of this dam of rock from the bed of the river, to a depth of twenty or thirty feet, and over a width sufficient to prevent inundation in times of high water, would be a measure extremely beneficial to a large district bordering on the two streams. A great extent of level meadow land along the Passaic, at present too wet to be productive, would be rendered dry and arable, and might become, when under the plough, some of the best grain land of the State. Such a step would, moreover, ameliorate the quality of the water in the wells of the district, materially benefit the roads, and, a consideration far above all others, it would improve the health of the inhabitants. The expense would be in the removal of the obstruction, and in the compensation to the owners of the water-power which would be destroyed, but its entire amount would fall far short of the great gain to the community, which many conceive would result from the undertaking.

GENERAL VIEW OF THE CIRCUMSTANCES UNDER WHICH THE MIDDLE SECONDARY ROCKS WERE DEPOSITED.

In the general description of the middle secondary system of strata presented in the beginning of this chapter, the notion was advanced, that these materials were deposited by an extensive

ancient river, having its source in the southern States, and its estuary in the region of the Raritan and the Hudson, and having its course for the most part southeast of the chain of the Blue Ridge and the Highlands. Several important facts connected with this trough, such as its present *configuration*, the uniform dip and direction of its slightly inclined beds, implying a steady current, their singular constancy of character, so indicative of one general source for the whole, and the obvious identity of their materials with the soils *now* furnished by the ancient rocks from whence we would derive these deposites, all go to confirm the above supposition.

When the details of the geological surveys of Pennsylvania, Maryland, and Virginia, now approaching to completion, shall have been united with the delineations herein given of this interesting group of rocks, the long and narrow tract which they occupy, will be seen to possess in a striking degree the features of a noble river, taking its rise in the primary region of the southern States, and meeting the ocean, probably, at and beyond the outlets of the Raritan and the Hudson.

The traveller passing along the red sandstone belt from the Hudson to the northern confines of North Carolina, will, if his mind be directed to these considerations, become early impressed with the accordant nature of the evidence which accumulates as he advances. In commencing his journey, he will see the whole formation, occurring in part still beneath in part above the present level of the ocean. Passing the Raritan, where, for a certain distance, the tide washes a portion of it, he will next find it on the Delaware, elevated above the ocean level throughout its entire width from Trenton to Durham. Advancing to the Schuylkill between Norristown and Reading, he will observe its height above the tide to have augmented; and crossing thence in succession the Susquehanna, the Potomac, and the James rivers, he will perceive the tract still gradually and uniformly to ascend, until it attains a level of several hundred feet above the sea, marking an inclination nearly corresponding to that which belongs to many of our large rivers now descending from the Appalachian chain into the ocean.

The progressive diminution in the breadth of the formation is strictly in accordance with these facts. At the Delaware,

adjacent to the presumed ancient estuary or mouth of this supposed stream, the width of the deposit amounts to *thirty* miles; at the Susquehanna to about *twelve;* at the Potomac to between six and eight, and at the James river to not more than *four* miles.

It may be objected to the argument above advanced touching the regular and gentle ascent of the formation towards the southwest, that the existing slopes of the whole district southeast of the mountains may have been produced during the elevation of the greensand and tertiary strata, at periods subsequent to that which witnessed the drainage of the red sandstone valley.

Did the scope of the present treatise authorize the detailed discussion of this curious point, we think that a comprehensive investigation of the existing levels of the respective tracts, or, in other words, the *relief* above the ocean of the several parallel belts of country conceived to have successively emerged from beneath the sea, would go far to convince us that the channel which received the red shale deposits, possessed to a considerable degree, at least its present gentle slope towards the northeast, *during the epoch of its formation*, which was apparently soon after the cessation of those disturbances which finally elevated the coal.

Let it be observed that the Kittatinny Valley, formed of rocks uplifted at the close of the older secondary or Appalachian epoch, has the same regular and gradual declension in level from the interior of Virginia to the Hudson which we find in the red sandstone belt of the parallel valley southeast of it. From an elevation in the vicinity of the New River, approaching one thousand feet above the level of the sea, it slowly descends northeastward, until, at the Hudson, its general surface rises not more than one hundred feet above the tide. While this is true of the plains occupied by the *older* and *middle secondary rocks*, no such variation in the level of the more recently lifted *tertiary* plain along the sea-board is discernible. From the Roanoke to the Delaware the tide every where penetrates this latter, and its surface in that distance does not descend probably more than one hundred feet. It seems, therefore, altogether improbable that the whole of the northeastward descent in the first two valleys, that northwest and that southeast of the Blue Ridge

chain, should have been acquired at the time of the elevation of the tertiary, or at any period later than that of the final drainage of the middle secondary trough. The disturbances of level which took place at the close of the *newer secondary* or greensand period are still further in favour of the same conclusion; for, while the strata of that date were raised to a moderate height, averaging sixty or eighty feet above the ocean in the latitude of New Jersey, they underwent no permanent elevation above the tide in the region further to the southwest, between the Chesapeake and the Roanoke.

That the almost universal inclination of the planes of deposition in the red shale and sandstone formation is the result of the oblique or slanting mode in which the sediment has been laid down by a rapid and *steady* current, and is not due to any upheaving action, admits, I conceive, of very little doubt. If it were a consequence of the latter cause, the vast width of the region in New Jersey over which this northwest dip prevails would imply a thickness for the deposit so enormous as to be beyond all precedent among stratified formations. But we have conclusive evidence of the comparative shallowness of this group of beds, in the fact, that, in several localities, even in the interior of the belt, it has been washed off in patches by denudation, so as to expose the subjacent Appalachian limestone, which appears in these places to have been the original floor of the basin. The denudation along the southeastern border of the tract has, in like manner, in many neighbourhoods, cut away the coarse sandstone and conglomerate beds—the first deposited, and undermost, by order of dip—making the now undermost layers to consist of the red shales. This could obviously not occur if the materials had been precipitated in a nearly level position, as in that case they would have spread themselves along the bottom of the trough too far to the northwest to be removed by local denudation along its southeastern margin.

The very general dip of the strata towards the northwest and north seems plainly to imply the side from which the sedimentary matter chiefly entered this valley. That the lateral influx was principally from the belt of country immediately bordering the basin upon the *southeast* there can be little doubt; and we have only to observe the nature of the rocks skirting that side of the

belt in a broad tract, the whole length from the Susquehanna to North Carolina, to find at once the red soil of which these strata consist. Throughout this distance, talcose, chloritic, and horn-blendic rocks compose nearly the entire zone of country lying immediately southeast of the red shale; and the red soil which they produce is so identical in aspect and composition with the shales, and is at the same time so *copiously* furnished by their disintegration, as to point plainly to these primary strata as the source of most of the matter of this middle secondary trough. If we conceive the northwestern side of the valley next the base of the hills to have been, as it probably was, the deepest portion, and the red ferruginous materials to have entered this large river from the neighbouring talcose rocks, by currents setting obliquely *across* and *down* the channel, we may at once explain, not only the origin of these beds but their inclined position, and their predominant northwestern and northern dip.

In attempting thus to account for the prevailing dip of the red shale and sandstone strata, I am aware of the local exception to be found in the southeastern inclination of the beds between Middlebrook and Pepack, and its seeming incompatibility with the above views. I would direct the reader's attention, however, to the peculiar position of the Mine Mountain, jutting out into the estuary of the red shale, considerably to the southeast of the general line of coast. It is easy to conceive that its influence must have been to intercept the regular northward current, and to deflect it over a certain area into a species of *eddy*, in which the sedimentary matter would of course assume an unusual direction in its gently inclined surfaces of deposition. Proceeding east from the Round Valley Mountain, we find the dip at the White Horse to be nearly northeast, then *east*, and near the mouth of the Lamington river, southeast, and beyond Somerville, nearly south, affording an almost convincing proof that such an eddy prevailed, and presenting ample evidence, if such were wanting, that the inclined posture of the strata is not the result of an elevatory action.

Respecting the variegated calcareous conglomerates which overlie the red sandstone formation, but little difficulty exists in explaining both their source and the nature of the circumstances which accompanied their production. The fragmentary materials

of which they consist, can be traced in every instance to the older rocks of the neighbouring hills immediately bordering the middle secondary plain upon the northwest; and we can discover a relation between the amount of the several kinds of pebbles, and that of particular sorts of easily abraded strata along the flanks of the valley. Thus, in every case where calcareous pebbles and a calcareous cement are abundant in the conglomerate, the older secondary limestone (Formation II.) may be seen at the base of the adjacent hills, and usually at an elevation that indicates it to have been sufficiently above the waves to undergo extensive destruction from a sudden and powerful rush of waters.

In order to account for such a violent denudation along the base of the Highlands, we have only to advert to the state of things attendant upon the outbursting of the trap. This rock, intersecting and overlying equally all portions of the red sandstone, both its earliest and latest formed beds, was manifestly of simultaneous date throughout the entire region. The violent agitation of the whole belt of country, and the vertical rising of the bed of the red shale valley to a higher level, would necessarily set into rapid motion the entire body of its waters. These, rushing impetuously along the shattered strata at the base of the hills confining the current on the northwest, would quickly roll their fragments into that confused mass of coarse heterogeneous pebbles which we see, and strew them in the detached beds of conglomerate which they now form. The protrusion of the trap, the formation and deposition of the conglomerate, and the elevation and final drainage of the whole red sandstone basin, have hardly been consecutive phenomena, so nearly simultaneous appear to have been these events. The whole time occupied by these stupendous changes must have been extremely brief, compared with the period which produced the main mass of the materials of the basin—the red shales and sandstones—which occupy so large a part of it.

Of the Middle Secondary Rocks of the Green Pond and Long Pond Mountains.

When describing the older secondary rocks of the long, straight, and narrow valley which separates the two principal ranges of

the primary strata of the Highlands, it was stated that those formations where they appear in the neighbourhood of Green Pond and Macapin Pond, were overlaid unconformably by a group of much newer date, conceived to have been produced in the middle secondary period. I propose to offer a brief account of the position, structure, and probable origin of these insulated strata.

Geographical range.—Tracing these unconformable rocks from New York towards the southwest, they are found to constitute a nearly continuous mountain chain, extending from the western side of Long Pond, past Macapin and Green Ponds, to a point west of Succasunny. From the State line to the Pequannock, the belt consists of a single ridge, somewhat broken down in some places by denudation—this is known as the Long Pond or Raffenberg Mountain; but from the Pequannock southwest for several miles the belt is double, the shorter range forming the Copperas Mountain, and the longer parallel one the Green Pond Mountain, ending north of Succasunny.

These ridges are for the most part remarkably straight, while their summits are nearly level. Throughout considerable distances they present a succession of bold precipitous escarpments, facing invariably the east-southeast. The strata dip in all cases towards the west-northwest, at an angle which is somewhat variable, but which is usually about 30°.

The almost perpendicular outline of these ridges on their southeastern side, the repetition of the same rocks in the two adjoining ranges, and their dipping towards the same quarter, are facts which strongly indicate the existence of one or more extensive longitudinal dislocations of the strata. We can hardly conceive how a mere denudation of the surface, unaccompanied by a disrupting movement along certain lines, could have given to the topography of this formation its present peculiar features.

The Green Pond Mountain terminates in three oval-shaped outlying hills in the prolongation of the main ridge, separated from each other and from it by transverse valleys or notches; through one of which the Morris canal has been carried. A fourth low hill, not precisely in the same line with the others, commences a little south of these and extends longitudinally towards Flanders. It would appear to belong to a different formation from the others,

being manifestly an insulated remnant of the sandstone, Formation I., of the Appalachian series.

Composition and Structure.—The formation we are describing embraces two principal members, which preserve their respective characters with very great uniformity. The lowest of these, which reposes sometimes on the primary rocks at the foot of the adjoining hills, sometimes on the lower strata of the older secondary series, originally forming the bed of the valley, is a conglomerate easily recognised. This rock consists of a rather fine-grained compact red sandstone, occasionally argillaceous, imbedding rounded, water-worn pebbles of various dimensions, generally composed of white quartz. When these pebbles are large and diversified in their colour and composition, as happens in certain beds, and when the paste is less abundant and more argillaceous than usual, the whole mass possesses a considerable resemblance to the less calcareous varieties of the Potomac marble. Bowlders of a rock having these features lie strewed in great numbers in many parts of the red sandstone region east of the Highlands, extending as far as the Hudson, and traceable to this stratum of the Green Pond Mountain.

In the inferior beds, the character of the rock is somewhat different; being in many places almost white, and consisting chiefly of a white sandstone, thickly studded with white quartz pebbles. These layers are conspicuously seen in the outlying low hills, near the southern termination of the Green Pond Mountain; they are also visible at many other points, as, for example, ten miles north of Macapin Pond. Their contiguity to a tract of white sandstone of the older series, Formation I., suggests this rock as the probable source of the arenaceous materials of these beds. We thus find in this, as in other formations, that the lowermost layers are derived from the more immediately adjacent rocks, being deposited during the first influx of the currents, before time had elapsed for the introduction of the sediments from more distant quarters. Ascending a little, the beds of the lower part of the conglomerate become progressively more tinged with the red matter, so prevalent throughout the higher portions of the formation.

The other division of the formation overlies the former, and is a compact argillaceous red sandstone, much resembling the firmer varieties of the red shale of the district east of the

Highlands. It is seen well developed about one mile north of the head of Green Pond, where it forms the point of the Green Pond Mountain, near the notch or dislocation which traverses it two miles south of the Pequannock. Both in this vicinity and in other parts of the range, this stratum is divided by a system of oblique cleavage joints, which cross the general plane of the dip nearly at right angles, having an inclination of about 45° towards the southeast. These joints impart to much of this rock a slaty structure, calculated readily to mislead the observer respecting the true direction in which these strata have been elevated. The conglomerate is in like manner jointed by planes of cleavage, but at far wider intervals; being divided into large massive cuboidal blocks. These joints observe the same direction and dip as those in the overlying fine-grained red sandstone and shale.

The total thickness of the formation, including the conglomerate and the red sandstone, probably exceeds six hundred feet; but from the appearance of great faults or dislocations in these strata, the determination of their precise depth is attended with much uncertainty.

Of the probable Origin of the Formation.—From the wholly insulated position of these unconformable strata, encompassed on all sides by rocks of older date, and from the nonappearance hitherto of any organic remains of a distinctive kind, by which to infer their age and mode of origin, we are prevented from arriving at any very satisfactory views regarding the particular circumstances under which they were produced. The striking analogy which they bear, however, to the strata of the middle secondary series both in composition and appearance, and their lying in the same unconformable manner upon the previously uplifted rocks of the Appalachian group, induce us to consider them as deposits from the same mass of waters. This suggestion acquires additional weight, when we reflect that the long and narrow valley embracing this belt of conglomerate and sandstone, opens immediately into the great basin of the middle secondary series. From the denuded condition of the southwestern portion of the Green Pond range, and from the apparently natural outlet which German Valley would afford for the waters in their passage across this mountainous district, it seems not improbable that these rocks

once filled the bed of this valley throughout its whole length as far as Clinton. At the final elevation of the red shale and sandstone rocks, if, as we suppose, *these* strata were also uplifted, the extensive dislocations to which they have obviously been subjected, will account for the removal of a portion of the beds, exposed as they must then have been to the full violence of the floods thus set in motion.

PART II.

GEOLOGY OF THE SOUTHERN DIVISION OF THE STATE.

Introductory Remarks.

The strata of the southern half of the State arrange themselves in two distinct groups, and belong to two separate periods. The oldest or earliest deposited of these groups is proved, by the character of its organic remains, to have originated during the latest eras of the *secondary period*, while the more modern belongs to an earlier epoch of the succeeding *tertiary* dates.

In tracing these deposits over any considerable area, we discover that the whole series, though nearly horizontal, possesses an appreciable dip towards the southeast. As a consequence of this slight inclination, the lower strata rise successively to the surface as we advance towards the northwest; those at the bottom of the series forming the northwestern boundary of the region, where they repose upon the more steeply dipping beds of the middle secondary and primary formations, between Trenton and the Raritan river.

A gently undulating line, drawn from Shark Inlet on the Atlantic coast, to Salem, separates the secondary and tertiary groups. The district to the northwest of this line comprises only the former, while that to the southeast contains the latter. The tertiary region is extensively overspread, however, by a deep covering of nearly white oceanic sand, destitute of organic remains. We are thus precluded, not only from ascertaining definitively to what precise date we ought to refer this superficial stratum, but the extent to which it conceals the tertiary and secondary deposits. The tracts in which the former are actually exposed near the surface, are comparatively inconsiderable.

CHAPTER I.

OF THE UPPER SECONDARY SERIES, EMBRACING THE GREENSAND FORMATION.

General Description.—Adopting as hitherto the ascending order, we shall describe first the upper secondary formations lying to the northwest of the line above designated. This series includes naturally five separate sets of beds, the characteristic features and composition of which, commencing with the lowest, are as follows:

First. A group of *sands* and *clays* of several colours and of somewhat variable constitution, but frequently of extreme whiteness and remarkable purity. Among these occur beds of pure potters' clay. This division of the general series rests, along its northwest margin, from the Raritan to the Assunpink, in an unconformable manner upon the middle secondary rocks, and from the Shipetaukin to the Delaware upon the upturned strata of the primary belt. It contains towards its upper beds much of the dark blue sandy clay, which is also associated with the overlying greensand, from which it is not separated by any well-defined limit.

Second. A somewhat mixed group, consisting of beds almost wholly composed of *greensand* in a loose and granular condition, alternating with and occasionally replaced by layers of a blue, sandy, micaceous clay. This is the "greensand formation," properly so called. The greensand having become extensively employed in agriculture as a fertilizer of the soil, the bed in which this mineral is the chief ingredient has acquired the name of marl. The various features assumed by these strata in the different parts of the extensive tract which they occupy, will be specified in another place.

Third. Immediately overlying the greensand formation near its southeastern border, we find several limited exposures of a yellowish granular limestone of rather crystalline structure, and frequently siliceous composition. This rock exists in rather

irregular thin flaggy bands, usually from one to three inches thick. Between these we often find thin layers of loose granular calcareous sand, identical, or nearly so, with the matter of the rock, but destitute of cohesion.

This formation contains a profusion of organic remains, many of which belong in like manner to the underlying greensand, though some occur in it alone. Resting usually in direct contact with the greensand stratum, it contains often a moderate proportion of the green granular mineral, sprinkled throughout its mass.

Fourth. A yellow very ferruginous coarse sand, containing sometimes a small proportion of the green mineral. This stratum is in some places thirty feet thick. In the Nevesink Hills and in one or two other localities, it occurs as a soft sandstone, containing hollow casts of several characteristic fossil shells of the greensand formation. Throughout much of the central portion of the greensand region, this bed is in the condition of a loose sand, but abounds in organic remains in the state of solid casts, showing the interior form of numerous bivalve and univalve shells. The thin limestone next under it being very partially developed, this yellow sand generally rests in immediate contact with the greensand deposit, the two beds sometimes blending almost insensibly into each other.

Fifth. Resting upon the former and constituting the highest ascertained member of the upper secondary series in the State, there occurs a coarse brown ferruginous sandstone, sometimes passing into a conglomerate. It is composed of translucent quartzose sand, small fragments of felspar, and pebbles of white quartz, cemented together by a dark brown paste of oxide of iron. The green mineral in detached grains is likewise a common ingredient. The position of this rock is usually upon the summits of the insulated outlying hills, which rise occasionally above the general plain of the "marl region."

In employing for these upper secondary deposits of the State, the title of "greensand series," and for one member of the group that of the "greensand formation," I wish not to convey the impression that I regard these strata as the equivalents in the strict sense of the word, of the greensand formation, so called, of Europe. The remarkable abundance of the green granular

mineral in some of these beds, and its existence in greater or less degree in all, besides the obvious identity between most of the fossil genera in this and the European group, suggest the propriety of adopting the above name, as characterizing the peculiar composition of the deposit, and its relationship to the rocks of a well known system in other countries. But much yet remains to be ascertained respecting the organic remains of the two deposits in the respective continents, before we can determine more than approximately the true amount of *affinity* subsisting between them. The existence of but *one or two species* common to the European and American formations, renders it indeed a question of much uncertainty, to what part of the cretaceous period as defined in Europe, we are to refer the origin of these deposits of New Jersey, nor are we able positively to decide, merely by the relationship of the genera, whether the cretaceous period embraces both the commencement and termination of the American greensand series.

SECTION I.

Of the Potters' Clay Formation; Geology of Middlesex and part of Mercer counties.

Geographical Range.—The southern edge of the middle secondary district marks the northwestern boundary of this formation, from the mouth of Lawrence's brook to the Shipetaukin creek, between which and the Delaware, the gneiss rocks of the Assunpink form its limit. Advancing southwestward, the formation occupies a narrow belt along the Delaware, from Bordentown to a point opposite New Castle, the southeast bank of the river being its northwest boundary. Its inferior beds do not appear in Pennsylvania, having been washed away by the currents which excavated this part of the valley of the Delaware.

In some places the river in its meanderings cuts across the belt almost to the southeastern margin, where it is bordered by the lower beds of the greensand deposit. This is the case at Bordentown, where the greensand approaches the Delaware within half a mile. Where the river on the other hand recedes towards the northwest, as for example opposite Tullytown, the lower beds of

the series are preserved; and hence we have in that locality the white clays and sands of the "clay banks."

This lowest division of the upper secondary series passes into the greensand formation by a gradual transition; we cannot, therefore, delineate very precisely, the limit which separates the areas of the two formations. It will be traced with as much minuteness as practicable when we give the ascertained boundaries of the greensand or marl tract, being the northwestern margin of that important belt. It will be sufficient for our present object to state that this line, bounding these inferior clays and sands on the southeast, ranges nearly parallel with the railroad which unites South Amboy with Bordentown, lying southeast of it at an average distance of about three miles. Between Bordentown and Salem it preserves a rather greater distance from the Delaware.

Besides the tract thus traced, embracing most of the deposits of pure potters' clay in the State, there occurs an isolated bed of remarkably pure white clay and sand, which obviously belongs to this formation: it lies between Woodbridge and the Raritan, having escaped the destructive diluvial action which has swept away so large a portion of these lower beds of the formation in other places.

Composition.—White and yellowish sands, and white-blue and mottled-blue, and pink clays, used in pottery, occur abundantly in the lower and middle portions of this formation. Higher in the series these beds become less predominant, and we meet with a larger proportion as we ascend, of darker, more ferruginous and carbonaceous sands and clays. A very common material among these is a *dark, sandy, micaceous clay.* This deposit when moist, is usually lead-coloured or a dark-blue, or sometimes almost black. In this state it is somewhat plastic, becoming as it dries, of a light bluish-gray colour. It is rarely free from a considerable proportion of ordinary siliceous sand and mica, both usually in a state of minute division. The dark colour seems chiefly to arise from a small quantity of carbonaceous matter in a diffused condition. Relics of vegetation, such as carbonized wood or lignite, amber, and retinasphaltum, often occur in it, but particularly the first. It exhales the smell of marsh mud, though this gives place occasionally to that of *sulphur*, emitted by

the decomposing *sulphuret of iron*, which is often copiously present.

To the reaction of the *alumina* and sulphuret of iron, assisted by the oxygen of the atmosphere, we are to attribute the incrustation of sulphate of iron and sulphate of alumina sometimes seen upon its surface, imparting to the mass an astringent and acid taste, and endowing it with properties very noxious to vegetation. Some layers, containing a larger quantity than usual of the sulphuret of iron, acquire even a brown colour at the surface, caused by the amount of the hydrated oxide of iron produced by decomposition. The impervious texture of this material, causes the water which reaches it through the overlying porous sandy beds, to appear along its upper margin in the ravines and other depressions of the surface wherever its outcrop occurs. Much of this water passing through the adjacent beds of greensand, which are often charged like the blue clay with the decomposing sulphuret of iron, becomes impregnated to some extent with the sulphate of iron, producing a precipitation under favourable circumstances, of the hydrated peroxide of iron, in the form of *bog iron ore*, and *yellow ochre*.

To exhibit more definitely the composition of this blue earth, I here submit a chemical analysis of a specimen procured from the base of the Nevesink hills, on the Raritan bay, which will show the average composition of a very abundant variety of the stratum.

Analysis of the Blue Astringent Micaceous Clay.

Silica, - - - - - -	35·75
Alumina, - - - - - -	39·25
Protoxide of iron, - - -	12·10
Sulphuric acid, - - - -	1·95
Carbonaceous matter, - -	1·00
Potash, - - - - - -	0·30
Magnesia, - - - - - -	0·25
Muriate of soda, - - -	a trace.
Oxide of manganese, - - -	a trace.
Water and volatile matter, - -	7·00
	97·60

That certain portions of this deposit may be rendered available for enriching the soil, I firmly believe. The statement already made, that there sometimes exists in it a considerable share of the *greensand*, in other words, of the fertilizing material of the marl, is enough to encourage those who possess it and not the genuine marl, to give it their attention. Notwithstanding the very frequent, we may say the almost invariable occurrence, of the astringent matters, which are in themselves so unequivocally deleterious to vegetation, certain precautions may be adopted, such as must make it a valuable auxiliary to the farmer in places where the genuine marl lies too remote. The recommendations respecting the mode of using it, will be found in the chapter on the economic geology of the greensand formation.

This material alternates both with the lighter coloured clays and sands already spoken of, and with the greensand, which it overlies in some parts of Monmouth county. It is well exposed for examination in the cuttings upon the Camden and Amboy railroad. Containing occasionally a small proportion of the green grains, and resembling somewhat, when moist, the true greensand or marl, it is frequently applied to the soil through a misconception of its true nature, to the serious detriment of the crop.

White Clay of Woodbridge.—About one mile southwest of Woodbridge, near the level of a small stream on the road to New Brunswick, there occurs an insulated deposit of white clay and white sand, in which both materials are of remarkable purity.

This local bed is surrounded by the red shale rocks of the middle secondary series, and would seem to be a remnant of the lowermost layers of the upper secondary group, lying in a depression of the surface where it has escaped removal during the general denudation of the strata.

Beneath about ten feet of reddish diluvial matter, derived from the adjoining red shale, we find a bed of pure white sand, regularly stratified, and dipping gently westward. Its thickness is about ten feet. This sand is much esteemed as an ingredient for the manufacture of fire bricks. Underneath the sand lies the

white clay, in a bed about eight feet thick; when dry it is very nearly white, some portions of it, however, have a very slight bluish tinge. It is much used in the manufacture of pottery and fire bricks. The purer varieties are admirably adapted for making the glaze for paper-hangings, being employed for this purpose.

About three-fourths of a mile southwest of this excavation, another similar deposit is exposed in some recent diggings. The clay at the latter place surpasses even that of the former in whiteness, and in its exquisite smoothness of texture.

In the descending order, the beds at this place are, first, diluvial matter ten or twelve feet thick, then a layer of sand, and under this again the clays between seven and eight feet thick. These consist of an upper bed, somewhat sandy, but well adapted for making fire bricks, two feet in depth, and a lower layer, also two feet thick, remarkable for its whiteness and fine texture. This latter kind is particularly esteemed for making the glaze for paper. Immediately below this lies another bed of pure clay, having also a fine texture. It is white with reddish or pink blotches; its thickness is from three to four feet. It is an observation of the workmen, that when the clay is pure the sand associated with it is so likewise.

White Clay, Albion Mill.—A similar deposit of white clay and sand, occurring like the last near the bottom of the series, is to be seen not far from the Albion Mill, about five miles southeast of Trenton.

The clay at this spot, though moderately white and free from ferruginous matter, is mingled with rather too large a proportion of fine white sand, to suit it for making the better kinds of stoneware. It is not improbable, however, that its composition is such as to fit it for the manufacture of good fire bricks.

Clay Banks of the Delaware.—About half way between Bordentown and Burlington, beds of clay of somewhat analogous composition occur along the southern shore of the Delaware, in the line of cliffs called the "Clay Banks." The deposit in this place presents more variety than is visible in the other localities described.

The clay, though in some layers nearly white, is in many places slightly tinged or spotted with pink or bluish stains. It is dug to

some extent and employed for making pottery. Besides the whiter varieties, there occur others of a dark blue colour, having more or less sand and ferruginous matter in their composition. Imbedded between the layers of clay are seams of white and yellow sand.

The clay beds of this locality would appear to occupy a middle position in the formation, being higher than those southwest of Woodbridge, but inferior to the strata of potters' clay near South Amboy, to be next described. They lie very nearly in a range with the white sandy clay seen near Albion Mill, with which also a dark blue argillaceous bed is associated.

Potters' Clay, South Amboy.—Somewhat higher in the order of stratification, we find beds of bluish white and mottled clay, well suited for the manufacture of a much esteemed variety of stoneware.

This highly useful material occurs in a bed several feet thick, ranging along the shore of the Raritan Bay from South Amboy, for a space of about two and a half miles, to the marshes called the Cheesequakes. The stratum is nearly horizontal. Its upper surface is washed by the tides upon the beach; a mile farther to the southeast, it rises twenty-five feet above the shore, and a few hundred yards beyond this, it gently sinks again, so that two miles from Amboy it is overlaid by the ordinary dark-blue astringent clay. There are two principal banks or quarries where this clay is procured on a rather extensive scale. In that nearest to South Amboy, which goes under the name of Churchill's bank, the mass has been excavated to the depth of twenty-five feet. The lowest bed, which is that principally used, is a grayish blue clay, which, on drying, becomes nearly white. Besides a large proportion of alumina, it contains a large quantity of silica, in a minutely subdivided condition. Scattered through it occur numerous *dark specks*, which seem to be sulphuret of iron in a state of decomposition. After the surface of this clay has been exposed for some time to the air, these specks acquire a light yellow colour, which most probably arises from the oxidation of the iron. It is a curious fact, that the clay in which these dark specks are seen, is preferred in the manufacture of the stoneware, for which the material is chiefly used. Resting immediately above this layer, there is a variegated or mottled variety, often most beau-

tifully stained with red, green, and other coloured blotches. This, which is called *peach blossom clay*, is mixed with the former sort to make a particular variety of the pottery. About a fourth of a mile further to the southeast is another very extensive clay bank, the property of Mr. C. Morgan. At this spot, the lowest layer seen above the beach, is a variegated gray sand of unknown thickness, its surface being near the level of the tide. Immediately upon it rests the bed of clay, which varies in thickness from nine to twenty-one feet. It closely resembles Churchill's in composition, and is a very superior clay for making the kind of pottery called stoneware. In one part of the bed the clay contains a little mica in very minute scales. This is said greatly to injure its value as a material for making pottery. Other portions contain the dark specks supposed to be useful. Some bands in this portion of the stratum are reddish, and furnish the peach blossom clay. A white astringent efflorescence, probably a sulphate of alumina and iron, or a kind of alum, is found upon a certain layer near the upper part of the bed. This seems to be derived from the decomposition of the sulphuret of iron, which appears to be a characteristic component of the whole series of strata of which this clay bed is a member. The upper surface of the clay, though slightly undulating, is pretty nearly horizontal. Immediately upon it there occurs in many places a layer of sand of a few inches thickness, which contains vegetable relics, such as fragments of wood completely carbonized, and in the state of lignite, and also small pieces of nearly pure charcoal. *Amber* also occurs here, called rosin by the workmen.

Resting on the top of this layer is a bed of variegated sand, streaked with white, gray, red, and other colours. This is in some places ten feet thick, and over it, at various elevations, is a layer, generally about two feet thick, of the tough dark-blue astringent clay, showing a yellowish efflorescence of copperas upon its exposed surface. It contains, as this material very frequently does, a good deal of mica in minute scales, and a considerable proportion of common siliceous sand. This upper bed increases in thickness as we advance towards the meadows of the Cheesequakes, and southeast of Morgan's excavations none of the underlying clay has been found. In all probability it lies a little below the level of the beach, though it is possible that it may either

thin out or graduate into the dark clay that elsewhere lies above it.

On the top of the uppermost bed of sand above described, but somewhat nearer South Amboy than the commencement of the dark astringent clay, there is a yellow and much coarser sand, extending up to the soil. In this place its total thickness above the white clay is twenty feet. The materials of this uppermost layer are sometimes as coarse as gravel; and it seems to belong to the superficial diluvium, as it has an irregular undulating outline which strongly contrast with the nearly straight surfaces of the beds beneath. A similar exhibition of the diluvial sand and gravel reposing upon the other sands and the dark clay here described, may be witnessed at various places upon the Camden and Amboy railroad, and also conspicuously in the banks at White Hill, where the line separating the two deposits is very distinct. It is *undulating*, as if the original surface of the lower bed had been scooped by the currents that carried along the sand and gravel now forming the upper or diluvial stratum.

ANALYSIS.

Potters' Clay, Morgan's Bank, South Amboy.

Description.—Mottled white and red throughout the mass, but more particularly on the surface; highly gritty between the teeth; by calcination at a full red heat becomes of a brick red colour.

In 100 parts it contains:

Silica, - - - -	67·6
Alumina, - - -	15·8
Peroxide of iron, - -	5·6
Water, - - - -	9·3
Loss, - - -	1·7
	100·0

SECTION II.

Greensand Formation—"Marl."

Geographical Range.—The second division of the upper secondary series, which, in allusion to its peculiar composition,

I have entitled the *greensand formation*, is by far the most interesting portion of the whole deposit, whether we consider the curious properties of its chief constituent, the interesting relations of its numerous fossils, or the highly valuable use as a fertilizing agent, to which a large portion of the stratum is applicable.

Dipping at a very gentle inclination towards the southeast, its lower layers rise to the surface, and are finally lost towards the northwest, along the irregular denuded margin already referred to as forming the southeastern limit of the underlying potters' clays. Traced in detail, this northwestern boundary of the greensand formation may be described with sufficient accuracy as commencing at the southern shore of the Raritan Bay, a little to the northwest of the western termination of the Highlands of Nevesink, about the mouth of Compton's creek. Its course from this point, where the underlying strata are seen to rise above the level of the water, is a little south of west, past the small village of Mount Pleasant, to Deep run. From Deep run, the visible limit of the greensand takes a nearly south direction for nearly two miles, and then a westerly one to the Matchaponix creek, which it crosses about two miles southeast of Spotswood. It next crosses the Manalapan, two miles above the mills marked on the map as Mount's, previously sweeping in a somewhat concave line to the southeast. Between the Manalapan and the Millstone streams, it presents a similar curve towards the southeast, appearing on the latter about half a mile above the spot called the Red Tavern. Thence, bending as before, first to the south and then to the west, it crosses Rocky brook, half a mile below Millford. From this point its course is first south to Empty run, then southwest to Doctor's creek, a little above Allentown, and then west-southwest along the southern side of the same stream to Crosswick's creek, which it passes about half a mile above the little village called Groveville. From Crosswick's creek to Burlington creek the line of the greensand is nearly straight, crossing Black's, Craft's, and Burlington creeks, each at points about one mile and a half from the Delaware. Passing the latter stream, it recedes somewhat from the river, meeting Rancocus creek about four miles above its mouth, near Franklin Park and Pensaukin creek, one mile west of Moorestown. Its course next, is a little more westward, to Cooper's creek, down which the stratum

extends, to within four miles of Camden. Sweeping again slightly to the south, the line reaches Timber creek, one mile and a half from the river. Thence its direction is nearly west-southwest as far as Raccoon creek, the line crossing in the interval Woodbury creek near Woodbury, and Mantua creek near Sandtown. Passing Raccoon creek about one mile below Swedesboro, it deflects more to the south, and pursues a nearly straight course to its point of termination near Salem, crossing Oldman's creek at Sculltown, and Salem creek about two miles west of Sharptown.

The undulations of this northwestern boundary of the greensand appear to arise less from any variations in the amount of the southeast dip, which is nowhere more than barely perceptible, than from the inequalities in the denudation of the stratum along its margin, and more especially from the irregular overlapping of the diluvial covering, which, particularly in the eastern side of Middlesex, conceals the true limit of the formation in all the higher tracts of ground between the streams, and gives to the visible boundary the curving outline alluded to. The denuding flood, which has evidently swept along the valley of the Delaware, seems, in curving to the south, to have cut away a large portion of the greensand, which originally extended southwest of Oldman's creek, giving to it a wedge-like form at its termination near Salem. The true strike or direction of the stratum would carry its northwest margin to the Delaware somewhere opposite Newcastle, as shown by the position of this side of the formation, where it reappears in the State of Delaware, in the vicinity of Bowersville. The oblique course of the denudation across the belt is further manifested in the nearly north and south direction of its margin on the western side of the river. In consequence of this, the southwest point of the formation in New Jersey lies opposite the general southeast margin in Delaware; and the northwest termination of the tract in the latter State, is in the prolongation of the general northwest edge already traced across New Jersey as far as Oldman's creek.

From the point where the northwest boundary of the greensand commences, the formation is exposed for a considerable height along the base of the Nevesink Highlands, the whole distance from Compton's creek to the mouth of the Nevesink

river. South of this point it appears along both sides of Shrewsbury river, east of the head of which it is seen skirting the sea coast. From about two miles north of Long Branch, southward as far as Shark Inlet, the stratum reaches almost to the ocean beach, being only hidden in places by a superficial covering of white sand, blown for a short distance inland from the shore. We do not find it either at the sea side or for three miles in the interior any where south of the estuary of Shark river. But a little west of the Poor House the edge of the formation crosses Shark river, and takes a gently undulating course towards the southwest.

In consequence of the wooded character of the country along the southeastern side of the greensand, and the irregular and obscure manner in which the white sands overlap this stratum, the southeast boundary is much less capable of being distinctly defined than that on the northwest. Aiming at as close an approximation to accuracy as the structure and condition of the region will permit, I have traced the margin of the formation from Shark river to where it crosses the Manasquan river, about one mile east of Squankum. Its general course thence is nearly westward until it is seen on Tom's river, which it crosses about a mile northeast of Goshen. Assuming in this neighbourhood a nearly southwest direction, and passing near the above village, it ranges about a mile to the southeast of New Egypt, and passes Scrabbletown to Rancocus creek, which intersects it about one mile east of Pemberton. Thence it passes about one mile and a half southeast of Vincentown, and a mile southeast of Medford, reaching Timber creek near Clementon. It lies rather more than a mile to the southeast of Blackwoodtown. On Mantua creek, the limit of the greensand is rather further to the southeast, being visible near a mill-dam about two miles in a direct line from Glassboro. Upon Raccoon creek, its position is nearly two miles to the southeast of Mullica Hill, and upon Salem creek about half a mile east of Woodstown. Pursuing the same general southwest direction, it is seen on Mannington creek, three-fourths of a mile to the southeast of Mannington Hill; beyond which to Salem, where it terminates, it follows very nearly the margin of the meadows of Fenwick's creek.

The belt embraced between the two lines thus delineated, has

the form of a long and acutely tapering wedge, the base of which is traced by the coast of the Atlantic Ocean and Sandy Hook bay—the point being marked by the limit of the firm land north of Salem. A slight inclination of the surface of this formation may be shown to exist uniformly from its northeastern towards its southwestern extremity. Independently of proofs derived from the known elevation of the country at various points, we have evidence of the correctness of this statement by merely observing the position which the belt occupies in relation to the streams in the different portions of its range. In Monmouth, where it is widest, it includes the head waters of nearly all the streams which empty either into the Atlantic Ocean, or the Raritan and Delaware rivers. But, crossing Burlington, Gloucester, and Salem counties, its position as we advance southwestward is nearer and nearer to the mouths of the several creeks entering the Delaware. The whole of the strata have been manifestly uplifted to a greater height in Monmouth than elsewhere, which circumstance, in connexion with the less extensive denudation of the northwest side of the belt, readily explains the breadth of the formation in that quarter.

The area here designated as including the whole of the visible greensand formation, embraces also several local, insulated tracts of the other overlying divisions of the upper secondary series. These are obviously but the remnants of strata which at one time spread themselves extensively over the greensand. The general southeast dip of all these deposits, renders their existence beneath the superficial sands of the region to the southeast extremely probable. To the almost universal destruction of the yellow sand and brown sandstone, which form the two upper strata of the series, we are to ascribe, I conceive, the deep and general covering of loose yellowish and white sands which conceal the rest of the formations throughout so large a portion of the region southeast of the greensand belt.

Composition of the Greensand or "Marl" Formation.

The greensand formation comprises, strictly speaking, several subordinate beds, all belonging, however, to two principal varieties. In the first of these, the green granular mineral is the pre-

dominant and characteristic ingredient. The second consists, on the other hand, of a dark-blue clay, mingled with more or less siliceous sand. This latter material constitutes the usual floor upon which the true greensand deposit rests; and it occurs, in like manner, especially in the northern and eastern portions of Monmouth county, both above the uppermost visible greensand, and included between its beds in one or more alternations. Appearances would seem also to indicate that these two deposits replace each other in the same bed, when traced for considerable distances. Indications of this passage from the one material to the other are chiefly discoverable in the lower portions of the formation, or along its northwestern margin. As the same dark clay, associated with the greensand, abounds throughout the upper portion of the next inferior division of the series, or that which we have styled the potters' clay formation, it is impossible distinctly to define the lower limit of the true greensand formation. I shall, for convenience sake, however, group all the strata below the lowest bed of greensand, with the division containing the potters' clay.

The external characters, and usual chemical composition of these blue astringent clays lying adjacent to the greensand, have been described in the previous section, when treating of the lower part of the series, to which deposits they more strictly belong than to the greensand. I shall confine myself, therefore, in this section to a description of that part of the present formation which mainly characterizes it, namely, the greensand deposit itself.

Composition of the Greensand.

Description.—The predominant and often the sole ingredient in this bed, is a peculiar mineral occurring always in the form of small dark granules, about the size of grains of gunpowder. their form is roundish, and they are often composed of two or three smaller ones united together, a distinctive feature, by which they may at once be recognised from other dark kinds of sand. Though they contain on the average nearly fifty per cent. of silica, they are not gritty, but may be readily bruised between the teeth, or upon the nail, and some varieties, when moistened, admit of being kneaded into a half plastic mass, like impure clay. The

prevailing colour of the grains is a *deep green*, though sometimes the tint is as light as that of verditer. It is often of a dull greenish blue, and not unfrequently of a dark chocolate colour.

Along the eastern side of the marl tract in Monmouth, Burlington, and Gloucester, the stratum comprises very generally two varieties of the greensand, distinct as to colour, and holding generally the same relative position to each other. The uppermost layer, where it appears (for it is not always present), is of a light and glowing green, having very nearly the hue of the green paint called *verditer;* while the lower one is the common dark variety, of a dull bluish-green, or sometimes of a dull blue colour from adhering clay.

In some instances, particularly where the material constitutes the soil, the granules possess a brownish colour, the consequence evidently of the protoxide of iron which they contain, having undergone upon the surface a change to the condition of the peroxide. The dull colour so usual to the surfaces of these grains, when contrasted with the brighter green within the mass, would appear manifestly to proceed from the same cause. Some shade of green may be pronounced to be the colour essential to this mineral, as all the deviations from this tint are attributable either to oxidation, or to a thin coating of clay, which frequently encrusts each grain, and from which the deposit is rarely altogether free. When a mass of the greensand or "marl" is washed, especially with water to which a small quantity of an acid has been added, we invariably find the granules assuming a bright green surface. This colour is also produced in all cases when we mash or bruise a grain, no matter what may be its colour externally. By crushing the grains upon a sheet of white paper, we have an easy and unerring test in the colour of the streak, by which to recognise this material from all other varieties of sand.

Though the green granular mineral here described, constitutes the essential and distinctive ingredient in the greensand stratum, it rarely exists unassociated with several extraneous substances, particularly *clay* and *white siliceous sand.* These constitute sometimes as large a proportion as fifty per cent. of the bed, causing much variety in its external aspect, and influencing materially its properties as an agricultural agent. The sand which

is generally white or semitransparent quartz, existing usually in relatively small amount, the clayey matter being ordinarily the most abundant. This latter is of several tints, but is commonly of a light gray or lead-colour. It is also occasionally chocolate-coloured, brown, and even nearly white. Coating frequently the surfaces of the green grains, it conceals their true colour, imparting its own hue to the entire mass. As it is somewhat adhesive when moist, it gives to the stratum where it is abundant the character of a partially plastic clay. Besides the white sand and this clayey material, we often find a minute quantity of finely divided mica mingled with the greensand.

Subjecting the marl in the compound condition in which it occurs in the stratum to analysis, mechanically performed, I have ascertained the relative proportions of its several ingredients for a great number of localities. A large body of results will be presented in the section treating of the economical details of the greensand formation. But in the mean time, with a view to exhibit the prevailing composition of the stratum, the seven following analyses are presented.

Analyses of the "Marl."

A specimen from the pit of William Little, near Middletown Point, Monmouth county.

The material at this locality is of a light stone-gray, inclined to greenish. Closely examined, the green granules are easily distinguishable. At a little distance it has the aspect of a light-coloured clay. The greensand procured from it by washing is of a light green colour.

When separated into its constituents, 100 parts, afford:

Greensand, -	46·73
Clay, - -	53·27
Quartzose sand, -	none.
	100·00

A specimen from Thorp's pits, near Squankum, Monmouth county, (upper part of the bed.)

This marl is of a dark leaden-gray colour, owing to the pre-

sence of a large proportion of clay. The greensand when freed from this adhering clay by washing, is of a dark green. Besides the clay, the mass contains a considerable proportion of quartzose sand.

100 parts, afford:

Greensand, -	58·36
Clay, - -	27·64
Quartzose sand, -	14·00
	100·00

A specimen from Horner's pits, near the Bridge, Hornerstown, Monmouth county.

The colour of this marl is a rather light green. After having been washed, its greensand though consisting chiefly of bright green granules, contains, also, some of a brown ferruginous colour. Besides a rather large amount of clay, this marl possesses a small per centage of quartzose sand.

100 parts, afford:

Greensand, -	75·90
Clay, - -	20·10
Quartzose sand, -	4·00
	100·00

A specimen from John Woolston's pit, one-fourth of a mile south of Birmingham, near Rancocus creek, Burlington county.

This marl is but slightly cohesive. Its colour is a leaden-gray. Being washed, the greensand exhibits a clear green colour; it occurs in small granules, with a little quartzose sand admixed.

100 parts, afford:

Greensand, -	82·60
Clay, - -	10·40
Quartzose sand, -	7·00
	100·00

A specimen from the pits of Mr. Hoffman, one mile and a half east of Barnesborough, Gloucester county.

In its native condition, this marl is of a rich green, rather lighter than the medium tint. The greensand which it yields by washing, is of a somewhat darker colour, but uniform. The granules are moderately large, and with very few intermingled grains of common siliceous sand. Minute grains of *carbonate of lime* occur in it, but in trivial proportion.

100 parts, afford:

Greensand, -	85·58
Clay, - -	13·42
Quartzose sand, -	1·00
	100·00

A specimen from Jonathan Riley's pits, at Woodstown, Salem county.

The marl of this locality is of a dark dull greenish gray, with a tint of brown. This colour is owing to the ferruginous character of its clay. It is almost entirely free from quartzose sand, but contains a very small amount of *carbonate of lime* in minute granules. When washed, its greensand is of a very deep tint, nearly black; some of the grains, however, are brownish.

100 parts, afford:

Greensand, -	88·28
Clay, - -	11·72
Quartzose sand, -	none.
Carbonate of lime,	a trace.
	100·00

A specimen from the farm of James Smith, Mannington Hill, Salem county.

This marl has a rather green colour, of the average depth of tint. When washed, the greensand is of a rich dark green.

100 parts, afford:

Greensand, -	88·80
Clay, - -	10·20
Quartzose sand, -	1·00
	100·00

Besides the aluminous and siliceous matters here recorded as usually present with the greensand in the general mass, there occur occasionally several other substances, which, though comparatively minute in quantity, are possessed of active properties. Some of these materials are probably deleterious, while some are undoubtedly beneficial in their action upon vegetation. The substances referred to are *carbonate of lime*, already mentioned, *sulphate of iron*, *sulphate of alumina*, *sulphate of lime*, and *sulphate of magnesia*; also, *phosphate of iron*.

They appear to be derived, mainly at least, from constituents in the clay, and only very partially, if at all, from elements in the greensand itself.

The *carbonate of lime*, in most instances, we can trace to fossil shells and other organic remains, imbedded in the stratum. The *sulphate of iron*, obviously proceeds from the action of the atmosphere and moisture on the *sulphuret of iron*, so abundant in the clay; and the sulphate of alumina from the union of a portion of the sulphuric acid thus developed, with the argillaceous earth of the clay; while the sulphates of lime and magnesia may result, either from the combination of the same acid with some of the lime and magnesia, sometimes present in a minute share in the green mineral, or more probably from its reaction on the carbonates of lime and magnesia, existing like the sulphuret of iron in an insulated state. The phosphate of iron, is no doubt derived from phosphoric acid, traceable to the animal remains, acting on oxide of iron.

Several of these substances develope themselves upon the mass of the marl after it has been dug and exposed to the atmosphere, in the form of a white efflorescence, encrusting alike the clayey matter and the granules of greensand, with a delicate crystallization resembling a light frost. Collected and carefully examined and analyzed, this efflorescence will be found almost invariably to consist when it is of a pure white, of either the sulphate of magnesia, or sulphate of lime, (gypsum,) the latter predominating; and sometimes, these two occur united. In some instances, we recognise it to contain the sulphate of magnesia, (epsom salts,) in sufficient quantity to be distinguishable by its taste. A yellowish tint and an astringent flavour are apparent when it consists chiefly of the sulphates of alumina and iron. The carbonate of lime

more generally shows itself, not in the shape of an efflorescence on the surface like the others, but dispersed in minute granules throughout the body of the marl. Many of these calcareous granules are *grains of dolomite*, analogous in composition to the magnesian variety of the limestone, which overlies the greensand; whence probably the true source of the sulphate of magnesia above referred to. When the traces of shells are very numerous in the bed, and their conversion into the *sulphate of lime* has happened on the large scale, the gypsum forms a conspicuous part of a soft white clayey matter derived from the shells and interspersed among the green grains. The mixed mass of carbonate and sulphate of lime is then usually in a yellowish white *chalky* condition. Sometimes we may detect the gypsum in the marl in the shape of small regular crystals of transparent *selenite*, at times so minute as only to be detected by the magnifier.

Various fossil shells and other marine organic remains, amounting to considerably more than *one hundred species*, are scattered through the greensand. They do not occur very evenly distributed, but lie together in groups or *colonies*, forming layers, often a few feet in thickness, which extend over moderately large spaces. These collections of fossils would seem to be most abundant in those parts of the stratum which consist largely of the greensand.

The water percolating through the overlying sands, and also through the pervious greensand itself, has effected, and is daily effecting, important changes in the condition of the shells and other fossils; sometimes replacing their carbonate of lime with oxide of iron, sometimes removing it altogether, and leaving a mere mould forming either an inner or an outer cast, and sometimes obliterating nearly every trace of their former presence. We can perhaps nowhere meet with a better exemplification of the various alterations induced by the infiltration of water through porous strata, than are to be witnessed in these greensands and their associated deposits, where numerous substitutions of the elements are continually in progress, and where every species of dissolving and cementing action is hourly going forward upon an extensive scale.

The oxide of iron, the chief sources of which, as I have hinted, are the sulphuret of iron in the clays of the greensand and the ferruginous particles of the overlying yellow sands, is frequently

so abundantly introduced into the marl stratum, as to act the part extensively performed by it in nature, of a *cement*, binding firmly together into a semi-rocky mass, the materials with which it is in contact. When this occurs, the marl is often rendered too hard to be excavated by the ordinary implements. When indurated or solidified from this cause, it is most commonly in the form of large round concretions, from the size of a bushel to that of a barrel, lying in horizontal layers, generally near the top of the stratum. These masses thrown out and exposed to the frosts of a winter, most usually crumble down into the friable state so essential to form a useful marl; and the material seems to be not in any way impaired in its virtues, from having been united in such firm cohesion. When the cementing action has proceeded farther, a regular stratum of indurated greensand rock exhibits itself. Such may be seen in some portions of the cliffs on the bay side in the Nevesink hills, large blocks of it strewing the beach, and offering some beautiful specimens of a fine brownish-green rock, in which the green granules are dispersed through a cement (or paste), deeply coloured by oxide of iron, giving the whole a pleasing variety of tint.

The above descriptions embrace the principal changes which the materials of the greensand formation seem to have undergone since their original deposition. They claim attention, not merely for the elucidation they afford of some of nature's most important operations, performed in her quiet laboratory by her silent but potent chemistry, but for the valuable practical suggestions they furnish concerning the greensand deposit in its interesting light of a fertilizer of the soil.

The total thickness of the greensand formation, estimating it from the bottom of the lowermost layers abounding in the green granular mineral to the overlying yellow ferruginous sands, or the limestone bed when this is present, may be stated approximately at about one hundred feet. The only place in the whole district where it is practicable to ascertain, with any approach to accuracy, either the depth of the formation, or the relative situation and number of the separate beds which it comprises, is along the shore of Sandy Hook bay in the cliffs of the Nevesink highlands. This, the only coast section of the strata, is still an imperfect one; large masses of the upper beds, fallen from above,

covering the lower deposits near the water side. It would appear from what we behold in these cliffs, as well as from evidence collected throughout the "marl region," that the greensand constitutes generally but a *single stratum*, conceived to be continuous beneath the whole district, and to be itself in many places, more than thirty feet in thickness. That it is occasionally divided into two or even more subordinate thinner beds by bands of clay and sand, which are sometimes interpolated, and swell to a thickness of several feet, is obvious enough from the features seen in many excavations. But it should rather be considered as a deposit remarkable for the permanency of its composition, thickness, and external features. Owing to the large amount of water which it usually contains, the greensand is rarely penetrated in the numerous diggings which are made in it for the marl, to a greater depth than about twenty feet, the pits becoming at that limit too wet to be prosecuted deeper.

In one or two instances, wells have been sunk through the stratum, and the depth of the greensand ascertained to be about thirty feet, as already mentioned.

Specific Gravity.—The specific gravity of the green granular mineral, carefully freed from all extraneous adhering matter is, according to several experiments cautiously made, about 2·65. Three different specimens, taken from remote localities, gave for the two lowest each 2·63; for the highest 2·70.

The hardness of this mineral varies materially, being dependent somewhat upon the time elapsed after it has been dug; it is softest when moist and recently uncovered. Freshly extracted, its hardness often does not exceed that of talc; but when long uncovered and dry, it nearly equals that of gypsum.

It would appear by experiment to be entirely insoluble in water, both cold and boiling; but it dissolves with tolerable facility in any of the stronger acids, though different specimens vary materially in this respect.

Chemical Composition of the Green Mineral.

From a number of analyses of the greensand, selected with the greatest care for the purpose, and ascertained to be entirely free from extraneous matter, it would seem that this mineral is not

quite uniform in its composition, but exhibits slight variations in the proportions of its principal constituents.

The following results will serve to display its prevailing chemical nature, and the moderate fluctuation of the several ingredients:

Greensand of Thorp's Marl, Squankum.

Description.—Colour, a dark olive-green; granules of a medium size; it composes 58·36 per cent. of the marl of the upper part of the bed, and 72·36 per cent. of the lower.

Composition.—In 100 parts:

Silica, - - - -	51·00
Alumina, - - -	6·50
Protoxide of iron, - -	21·55
Potash, - - - -	10·50
Lime, - - - -	a trace.
Magnesia, - - -	1·08
Water, - - - -	9·00
	99·63

Greensand of Joseph Vanderveer's Marl, Freehold, Monmouth county.

Description.—Colour of the granules, rich green; size, small; composes 70 per cent. of the upper part of the bed, and 92 per cent. of the lower.

Composition.—In 100 parts:

Silica, - - - -	50·00
Alumina, - - -	7·00
Protoxide of iron, - -	22·00
Potash, - - - -	11·00
Lime, - - - -	1·00
Magnesia, - - -	a trace.
Water, - - - -	9·00
	100·00

Greensand of the Marl of Poke Hill, near Plattsburg, Burlington county.

Description.—Colour of the granules, a rich dark olive-green;

their size, rather above the medium; composes 98 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - - -	50·75
Alumina, - - -	6·50
Protoxide of iron, - -	22·14
Potash, - - - -	12·96
Water, - - - -	7·50
	99·85

Greensand of the Marl from the Pits of Thomas Edwards, Burlington county.

Description.—Colour a rather light grayish green; the granules somewhat less than the medium size; it forms 93·51 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - - -	51·00
Alumina, - - -	6·75
Protoxide of iron, - -	22·00
Potash, - - - -	11·00
Lime, - - - -	a trace.
Magnesia, - - -	none.
Water, - - - -	9·00
	99·75

Greensand from the Marl at Evesham, Burlington county.

Description.—Colour of the granules, a medium tint of green; their size rather large; constitutes almost the whole of the marl.

Composition.—In 100 parts:

Silica, - - - -	48·50
Alumina, - - -	7·50
Protoxide of iron, - -	22·80
Potash, - - - -	11·00
Water, - - - -	9·50
	99·30

Greensand from the Marl of Josiah Heritage, two miles and a half east of Barnesborough, Gloucester county.

Description.—Colour of the granules, a very dark olive-green approaching black; size rather large; forms 93·70 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - - -	47·50
Alumina, - - -	7·84
Protoxide of iron, - -	23·78
Potash, - - - -	11·11
Lime, - - - -	0·50
Water, - - - -	9·00
	99·73

Greensand from the Marl of Michael Allen's pits, one mile and a half east of Mullica Hill, Gloucester county.

Description.—Colour of the granules, brownish green; they are of about the medium size; constitute 96·36 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - -	48·50
Alumina, - - -	7·00
Protoxide of iron, - -	21·40
Potash, - - -	12·90
Lime, - - - -	a trace.
Magnesia, - -	1·00
Water, - - -	8·80
	99·60

Greensand from the Marl of Elijah Horner's pits, one mile and a half southwest of Mullica Hill, Gloucester county.

Description.—Colour of the granules, a rich green, rather darker than the average; size, large; forms 90·75 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - - -	51·09
Alumina, - - -	8·23
Protoxide of iron, - -	21·99
Potash, Magnesia, - -	14·06
Water, - - - -	5·51
	100·88

Greensand from Marl of Benjamin Coulson's pits, three miles north-east of Woodstown.

Description.—Colour of the granules, a dark rich olive-green; size, rather large; constitues 90 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - - -	48·35
Alumina, - - -	9·35
Protoxide of iron, - -	20·86
Potash, - - -	11·73
Lime, - - - -	0·50
Water, - - - -	9·00
	99·79

Greensand from Marl of Allen Wallace's pits, two miles and a half west-northwest of Woodstown, Salem County.

Description.—Colour of the granules, a dark green; size, rather large; constitutes 90 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - - -	48·40
Alumina, - - -	7·30
Protoxide of iron, - -	23·00
Potash, - - -	11·47
Lime, - - - -	1·20
Water, - - -	8·15
	99·52

Greensand from Marl of Jonathan Cauley's pits, three-fourths of a mile northwest of Woodstown.

Description.—Colour of the granules, a rather dark olive green; size, large; constitutes 86 per cent. of the marl.

Composition.—In 100 parts:

Silica,	48·45
Alumina,	6·30
Protoxide of iron,	24·31
Potash,	12·01
Lime,	a trace.
Water,	8·40
	99·47

Greensand from Marl of Samuel White's pits, Woodstown.

Description.—Colour of the granules, the medium tint of gree size, somewhat large; composes 88·26 per cent. of the stratum

Composition.—In 100 parts:

Silica,	50·16
Alumina,	6·00
Protoxide of iron,	24·74
Potash,	11·70
Lime,	a trace.
Water,	7·00
	99·60

Greensand from Marl of Paul Scull's pits, three miles northw of Sculltown, Salem County.

Description.—Colour of the granules, a very dark green; co poses 91·5 per cent. of the marl.

Composition.—In 100 parts:

Silica,	51·50
Alumina,	6·40
Protoxide of iron,	24·30
Potash,	9·96
Magnesia,	a trace.
Water,	7·70
	99·86

Greensand from Marl of James Smith's pits, Mannington Hill, near Salem.

Description.—Colour of the granules, a rich dark olive-green; size, rather large; forms 88·8 per cent. of the marl.

Composition.—In 100 parts:

Silica, - - - - -	50·00
Alumina, - - -	6·99
Protoxide of iron, - -	20·99
Potash, - - -	10·99
Water, - - -	10·00
	98·97

Comparing the details of these several analyses, we perceive that the greensand even when of the greatest purity is not absolutely constant, either in the nature of the ingredients which enter into its composition, or in their relative proportions. The per-centage of the *silica* is seen to vary from 47·5 to 51·5; that of the *alumina* from 6 to 9·35; that of the *protoxide of iron* from 20·86 to 24·74; that of the *potash* from 9·96 to 12·96; and that of the *water* from 5·5 to 9·5. We find, moreover, that, in some instances, besides these elements, *lime* enters into the constitution of the greensand, in other cases magnesia; while occasionally both occur. The amount of these earths is, however, always inconsiderable.

From the above series of analyses it appears that the mean proportion of the *silica* is approximately 49·5 per cent.; that of the *alumina* 7·3; of the *protoxide of iron* 22·8; of the *potash* 11·5; and of the *water* 7·9 per cent.; while the *lime* when present seldom exceeds *one half per cent.*, and the magnesia is rarely more than a mere trace.

A comparison of the greensand of New Jersey with that of Europe shows no essential difference in their chemical nature. *M. Berthier*, an able French chemist, has analyzed that of the vicinity of *Havre*, in France, and reports the following as its composition.

Greensand of Havre, in France.

Composition.—In 100 parts:

Silica, - - - - -	50
Alumina, - - - - -	7
Protoxide of iron, - -	21
Potash, - - - - -	10
Water, - - - - -	11
Loss, - - - - -	1
	100

The late lamented chemist, Dr. Edward Turner of London, also examined with great care the chemical constitution of the greensand of Kent, in England.

His experiments gave in the 100 parts:

Silica, - - - - -	48·5
Alumina, - - -	17·0
Protoxide of iron, - -	22·0
Potash, - - -	*a trace.*
Magnesia, - - -	3·8
Water, - - - -	7·0
	98·3

The absence of potash in the green granules of the English greensand, and the large proportion of magnesia are facts not a little remarkable.

ECONOMICAL RELATIONS OF THE GREENSAND FORMATION.

Abundant evidence might be adduced to prove that the true fertilizing principle in marl is *not lime* but *potash*. The analyses which have been made, give us in several cases no lime at all, and where a small proportion of lime is present in the green granular mineral, it is in a combined state, chemically united with the other ingredients, and not traceable to the organic remains, which are in many of these instances not present in the stratum. Besides, the quantity of shelly matter, even where the shells are plentiful, is so

the land. Nevertheless, as some feebly beneficial effects may
y arise from this source, it may be of service to the agri-
st, in choosing between different fossiliferous marls, to at-
the nature of the particular fossils, and the state of more
decomposition or change in which they are to be found.
t be borne in mind, that a large portion of the visible marl
n is immediately overspread by a very porous layer of yel-
rruginous sand, and that this introduces to it a perpetual
of water, furnished with great regularity as from an *im-
filter*. From the upper or *ferruginous sand* it must descend
d often with a considerable amount of the oxide of iron,
be seen in the abundant ochreous sediment which it almost
deposits as it issues from the surface or upper part of the
ed. It is ready, therefore, to precipitate this oxide of iron
ny substance capable of displacing it from the water, and
g with the more soluble carbonate of lime of the shells, an
ange of materials arises, and the calcareous matter of the
s dissolved and carried away, while the oxide of iron takes
ce. Hence we often see the shells of a deep yellow or brown
, and upon inspection they are found to consist less of car-
of lime than of oxide of iron. In such case they are to
arded as wholly inert upon the soil, as, in fact, so much
matter, usurping the place of a far more serviceable sub-
, the greensand or marl. But this is not the only change
seems to have been effected in the foreign materials of the
w this unceasing infiltration of water. I have before alluded

bonate of lime derived from them. These two substances coming together in a state of solution, a chemical reaction, of course, ensues, both the sulphate of iron and carbonate of lime are decomposed by the mutual affinities of their ingredients, and the result is a precipitation of the oxide of iron of the former, and a combination of the sulphuric acid and the lime to form sulphate of lime or *gypsum*. That such is the fact is apparent from our finding, in many cases, a sensible amount of gypsum, either in the earthy state or in minute crystals intermixed with the marl; and from our observing besides, that when the gypsum is in greatest plenty, we can most generally discover a strong sulphurous odour, an evidence upon grounds before explained of the existence of sulphuret of iron, undergoing a conversion into the *sulphate of iron*. It will suggest itself to every one, that the existence even in small quantities of so potent a stimulant to vegetation as gypsum, must have a powerful influence in modifying the useful properties of the marl containing it. Yet it must not be inferred from this, that the efficacy of the greensand is owing to the gypsum which I have shown to be frequently present. The comparative inertness of plaster upon the sandy soils of parts of the region where the marl has never been applied, as in several places near Salem, is a fact in itself sufficient to overthrow this notion, even if it were not true that very many marls which do not contain gypsum in any shape, are endowed with the highest fertilizing power.

Directions for Selecting and Analyzing the Greensand.

The valuable fertilizing properties of the greensand, and the extensive use which is made of it in agriculture throughout nearly the whole of the region which it occupies, suggest the propriety of our offering in this place, some practical directions for selecting, analyzing, and applying it.

In seeking for the marl stratum in neighbourhoods where it is likely to occur, but where a covering of any of the superficial deposits obscures it, the primary point to be remembered is, that the true greensand stratum is the lowest accessible deposit of the region. We should find out, therefore, the *deepest depressions* of the land, such as the meadows and natural ravines, and by the use of an auger or other instrument for boring the ground, several feet in length, ascertain whether the stratum lies suffi-

ciently near the surface to be easily and economically uncovered. A rather sure guide to the marl is afforded by the aspect and composition of the earth existing at and near the surface. Should it be at all *greenish*, or contain upon close inspection, any of the green granules, the probability is that the marl lies beneath at a very moderate depth, and the chances augment when we find our borings bring up an increasing proportion of this mineral as we descend. I have repeatedly found the position of the marl stratum indicated by the trickling forth of the water from the foot of a bank, for the water is almost invariably seen to issue along the top of either the dark clay or the true marl.

For judging of the quality of a marl by observation, some familiarity with the multiform aspects which it assumes is indispensable. The leading rule, however, is to bear in mind that the fertilizing efficacy of the compound, resides in the minute round greenish grains which compose most, or sometimes all of it; and that it seems, moreover, to be dependent upon the proportion in these green grains of those powerful alkaline stimulants to vegetation, *potash* and *lime*, but especially potash. The first thing then, is to approximate to the relative quantity of the green grains in the whole mass, and this may be effected with a greater or less degree of accuracy in several ways. The simplest and readiest method is to employ a small pocket magnifying-glass, and to become familiar with the dark-green grains, so as to distinguish them at once from other dark varieties of sand which sometimes occur associated with them. A little practice will very soon enable one to use the glass expertly, and to arrive at a pretty true estimate of the probable per-centage of the green granules. But as these granules cannot sometimes be distinguished from the grains of ordinary white flinty sand, or from other kinds, in consequence of the particles being *all alike coated* with a thin film of the dark cementing clay, it will be useful to adopt some method of bringing out under the magnifier their different characteristics of colour and form. Let the mass be washed in a large glass tumbler, and repeatedly agitated with the water until as much of the clay as possible has been detached from the grains. After pouring off the turbid water by repeated rinsings, and permitting it to settle until clear, we may estimate the comparative quantity of clay in different marls by the relati[redacted]

amount of sediment which subsides. If we wish to be more accurate, we can weigh out a given quantity of the marl, then pursue the above plan, and decant the clear water from the clay; and after thoroughly drying the clay, weigh it to ascertain its amount. Having got away most of the clay, we should spread out the granular matter upon a sheet of paper and dry it, when there will be no farther difficulty in distinguishing, by their colour and lustre, the foreign impurities from the grains of true marl; and also of estimating the relative abundance of each. When the marl to be examined contains much clay, I would recommend the experiments to be made upon a regularly weighed quantity, weighing both the clayey and the granular portions. A delicate apothecary's balance will commonly be found accurate enough. Another more expeditious, though less accurate method, is merely to dry the marl, spread it extremely thin upon a sheet of white paper, and then hold it near a window or in the light, to examine it carefully by the magnifier. The flinty sand, though stained with clay, may then be clearly discerned in consequence of its transparency; whereas when we inspect a solid lump, all the particles upon the surface are nearly alike dark.

A useful suggestion is, to place a portion of the marl upon a hot shovel or on the top of a stove, when all the granules will change from their ordinary green tint to a light red or brick colour, while the other materials of the mass sustain little alteration. This will often render obvious to the naked eye the proportion of the green grains.

When there is a yellowish or whitish incrustation upon the marl after the *moist* surface has remained for some time exposed to the weather, it is indicative of the existence of a portion of either copperas or sulphate of alumina, the hurtful nature of which has already been explained.

An astringent inky *taste* will very often detect the presence of these noxious substances at times when no such efflorescence shows itself. If the quantity be too small to betray them distinctly to the palate, and we are still in doubt as to their presence, other more rigorous tests are within our reach; and as these astringent matters are so unquestionably pernicious in their action, it is of importance to have the means of determining in what proportion they abound in different marls. This can be effected with

precision only by a systematic chemical analysis, but their existence can be made to appear by the following simple tests. Put a small portion of the marl in a flask or other thin glass vessel; pour upon it some pure water, and heat it moderately. After causing the water to dissolve in this way as much as possible, remove the heat, and let it settle; then decant the *clear* fluid into some glass vessel, such as a wine-glass. If there is any copperas present, it will be evident upon adding to the fluid a little lime-water, which will produce a milky turbidness that after a little while will become stained of a yellowish-brown colour. The milkiness is owing to the formation of gypsum, and the brown colour to oxide of iron from the copperas. Or in lieu of this, add a solution of oak bark; and if copperas be present, we shall have a dark inky colour at once produced.

A good marl will, upon being squeezed in the hand, fall asunder again rather than bake into a tough doughy mass; and upon being left in heaps to dry, will assume a light grayish green colour and be extremely *crumbly*. It seems to be a very general characteristic of the better class of marls, that they throw out a white efflorescence or crust upon those grains which are most exposed to the air: hence the very light colour externally which some heaps of marl possess. This crust I have already shown to consist usually of the sulphate of lime (gypsum), sulphate of magnesia, and carbonate of lime. A drop or two of strong vinegar, or any strong acid, will produce an effervescence or *frothing* if it be the *carbonate* of lime; and should nothing of this kind take place, we may set it down to be *gypsum*. Of course, from the minuteness of the quantity of the white coating, much care and accuracy of observation are demanded in doing this, in order to avoid erroneous conclusions.

Marls deemed equally good with the kind showing the efflorescence, very frequently occur, exhibiting none of the white incrustation.

It does not seem that any general rule can be given for distinguishing the fertilizing properties of a marl by its mere *colour*, as it must appear from what has been said, that the peculiar shade of colour is frequently owing to the colour of the intermingled *clay*. When the mass, however, is comparatively free from clay or common sand, and consists of little else than the greensand,

observations go to show that the rather *dark* green variety is more potent in its effects than the very light green, which sometimes overlies it.

The presence or absence of shells I look upon to be a point of but little moment, for I find that several of the most active marls in the region show no traces of fossils. The whole amount of carbonate of lime in the shape of fossils, and in that of the occasional white incrustation upon the grains, can in very few instances amount to *one per cent.*; while, as analysis shows, the lime chemically combined with the other ingredients in the green grains, is sometimes *one per cent.*, and the potash nearly *twelve per cent.*

There yet remains, however, a more important, and by far more difficult inquiry, namely—into the *exact* constitution of the green grains, in order to determine the per-centage of the several ingredients—or the richness of the marl in *potash* and *lime*. I had entertained hopes that the external aspect of the grains might perhaps depend in part on the presence and proportion of these bodies, and that *mere inspection*, after multiplied analyses were made, might enable any one following certain directions, to inform himself whether a marl abounded in these essentials or not. But, I find that so far from being a mineral of definite and constant proportions, as some mineralogists have regarded it, the greensand is in fact a compound which fluctuates considerably in its external characters, and its chemical composition. The numerous analytical results which I have presented, will abundantly prove this. It is manifest, therefore, that we possess no shorter method to discover the *exact* quantity of the potash, than to subject the marl to a systematic chemical analysis.

Three different plans have been pursued in procuring the composition of the marls described in this work. The *first* consisted in separating, mechanically, that is to say, by washing and selecting the several ingredients, the greensand, the clay, and the quartzose sand, together with any carbonate of lime which may be present. The *second*, in analyzing systematically the green granular mineral, with a view to determine accurately its constitution. The *third*, in partially analyzing the marl for the purpose of ascertaining the proportion of its chiefly efficacious element, the potash. Besides determining the relative quantity of potash

by the two latter methods, it has been approximately estimated for a series of specimens too numerous to be subjected to the more operose process of analysis, by ascertaining by the first mode the amount of the green mineral, and then calculating, from the average per-centage of potash, the proportion in which it prevails in the particular marl.

Though it is not presumed that among those engaged in agriculture, more than a very few persons possess the requisite chemical skill, or the facilities for this species of research, yet for the sake of such as may chance to be competent to execute this kind of analysis, I have thought it well to introduce a statement of the method of analyzing the mineral in question. Several plans, modifications of the same general method, have been tried for the purpose of arriving, if possible, at some mode sufficiently simple to make it practicable by those who possess but a limited knowledge of analytical chemistry. But the nature of the compound seems not to admit of either a very direct or expeditious mode of operation.

Method of analyzing the Greensand.

1. Digest the mass in a flask with pretty strong muriatic acid, by a sandbath heat for at least three days, or boil it actively for five or six hours. Every thing is dissolved but the *silica*, which must be filtered, ignited, and weighed.

2. Precipitate the *oxide of iron* and *alumina* by ammonia and estimate them together, and detach the alumina by *caustic potash.*

3. Evaporate the ammoniacal solution to total dryness, and heat the mass to incipient redness, to expel the muriate of ammonia. There remain the chlorides of calcium, magnesium, and potassium, which redissolve in water, dividing the liquor.

4. To one half add oxalate of ammonia, and separate the lime, then by ammonia and phosphate of soda separate the *magnesia.* Subtract the combined weight of these two computed as chlorides, from the original triple chloride, and we have the *chloride of potassium.*

5. Now evaporate the other half again to dryness, and dissolve up all the chlorides of calcium and magnesium by *alcohol*, and dry and weigh the residual chloride of potassium. If further

check is necessary, convert this into chloroplatinate of potassium, and estimate the potash from this.

Suggestions for correcting the Noxious Effects of the Astringent Clay underlying and associated with the Greensand, and for using it as a Marl.

From the descriptions of this stratum already presented, it appears that the action of this astringent mass upon the crop is decidedly pernicious, when the material is employed in any amount beyond the most stinted doses; and the cause of its poisonous property would seem, judging from the chemical analyses made, and from other evidence, to be attributable to the acid reaction of the astringent ingredients which it possesses, namely, the *copperas* and *sulphate of alumina.*

Copperas, though a neutral salt, is well known to chemists to exert an *acid reaction*, and hence we are not to be amazed that a clay containing it in obvious quantities, should burn, or more strictly *poison*, the vegetation. Knowing, as we do, the source of the deleterious properties of the clay, a few simple correctives suggest themselves, and such as any one wishing to use this substance as a substitute for marl may adopt.

My first recommendation to the farmer who is about to make use of this clay upon his soil, is, that he be careful to select, when he has the choice, that variety which contains the green granular material of the true marl, and to avoid altogether the kind which is wholly destitute of this substance. When the green grains are pretty numerous in the mass, as they are near Spotswood, Burlington, Camden, and generally upon the northwest side of the marl tract, I would then advise its use, but guarded by the following precautions. Let the clay be dug several months before it is to be scattered on the land, and let it be spread out in broad, *shallow*, flat heaps, where the rains may soak through it and carry away the copperas and sulphate of alumina, which, from their well known solubility, will be easily dissolved and washed out. The green mineral does not dissolve in water, and hence, while the rains will purify the mass, no loss of its more active portions can happen. Numerous attempts at using this clay as a marl have shown, that though noxious at first, it is often permanently

beneficial to the land, after the second, third, or fourth year; a fact which I attribute to the gradual escape of the astringent matter by the rain. Though I do not think that the exposure of even an entire winter will always suffice to rob the clay of all the sulphates (copperas, &c.) which it may contain, yet it bids fair to do much good, and therefore deserves a careful trial.

I have to offer another, and I think, far more promising suggestion, for making the better portions of this stratum beneficial in their effects upon the soil, Chemists are aware that both the sulphate of iron and the sulphate of alumine are decomposed by *caustic lime;* and the antidote I propose is founded upon this fact. My recommendation is, to add to every heap of this spurious astringent marl, a small quantity of *freshly burnt lime*, and to mingle them thoroughly together. The sulphuric acid of the copperas or alum earth, or of both if present, will pass over to the lime and form sulphate of lime (*gypsum* or *plaster*), the value of which, as a stimulant to vegetation, is well understood; the other ingredients, the oxide of iron and clay, will on being liberated, contribute also towards improving the texture of the soil should it be sandy. A bushel of lime to every hundred bushels or five tons of the mass, will in most cases be sufficient to neutralize all the astringent matter present, and to convert it into, or rather replace it by, *gypsum.* The dressing of an acre of such a mixture will contain of the green marl, of gypsum, and of uncombined lime and lime in a state of carbonate, in all probability fully enough to impart to the soil a most decided improvement in point of fertility.

Lastly, I would recommend, for this astringent marly clay, the same course so appropriate also in regard to lime: I mean the practice of making a *compost* of the substance with the common *manure of the farm.*

This, like the former suggestion, is justified by good chemical reasons. In the fermentation of animal manure, *ammonia* always escapes in greater or less quantity; and ammonia, like lime, has the power of decomposing the sulphates of iron and alumina. In this case, however, gypsum is not a product.

From what is here said, it will be obvious, that when a field has been made *sterile* by the indiscreet use of this caustic clay, a

ready and certain remedy will be found by spreading upon every acre a few bushels of newly made lime.

Should these hints, which are designed to render useful certain portions of this lower stratum, receive their final corroboration from experience, we may consider that the area of the region susceptible of improvement by marling without the expense of hauling the material from a distance, has been in many districts doubled or tripled in extent. To ascertain whether the clay possesses a sufficient share of the green granules to warrant a trial of it upon the land, it may be necessary to employ the aid of a small *magnifying-glass*, which will be found by every farmer to be of indispensable use in the discrimination of all greensand marls.

SECTION III.

Limestone of Salem, Gloucester, and Burlington counties.

Resting immediately over the greensand formation, we find occasionally the locally developed and thin calcareous rock which we have defined as the *third formation* of the upper secondary series. Though unimportant as regards its thickness and the extent of surface which it occupies, it derives value from its usefulness as a source of lime, in a district having no other calcareous stratum, while considerable interest attaches to it, from the number of its fossils, and its affinity to an extensive and thick formation in the southern States, the *lower* limestone of Alabama.

Geographical Extent.—The general range of the stratum is from a point a little northeast of Salem, past Woodstown, Blackwoodtown, Mullica Hill, Vincentown, and New Egypt to Prospertown; beyond which I have been as yet unable to discover a trace of it. But it is not to be inferred that it exists as a stratum of much extent or importance throughout all of this long line. It has hitherto been detected at distant points only, and nowhere but in Mannington, Salem county, does it cover a wide area, or possess more than a very insignificant thickness. It lies along the southeastern edge of the visible marl tract, and if it dips at all, it is towards the southeast, to underlie the ferruginous sands. At its

greatest width, four miles northeast of Salem, it can be traced over a breadth of three-fourths of a mile. Its thickness in the same neighbourhood, as proved by a well sunk through it, is as great in one spot as *twenty feet;* though elsewhere in the same vicinity it is not more than six or eight. Near Vincentown it seems to be still less; and upon the branches of Crosswick's creek, it is reduced to less than one foot. The stratum preserves its prevailing structure and position, at its several localities, leaving us in no uncertainty as to its identity.

Composition and Aspect.—This rock is usually a soft yellowish or straw-coloured limestone, with a structure varying from subcrystalline to coarsely granular. It is often replete with organic remains, the disintegrated shells and corals, and other fossils, composing a considerable portion of the mass. Much of the rock contains impurities, as sand, clay, and oxide of iron; and its value as a limestone is therefore very variable. At times it is little else than a sandstone, in which the sand is cemented together by a trace of lime. It occurs with this character in loose rounded masses, resting above the marl, at Woodstown. Again it exists as a firm calcareous rock. This is its state in some places near Salem, in Mannington township. In the several accompanying analyses, the composition of the leading varieties of the rock may be accurately seen. This limestone is nowhere to be found in thick massive strata; on the other hand, it occurs only in thin horizontal beds, or irregular layers, not often more than four or six inches thick, and commonly separated by a thin parting of sand and carbonate of lime in small grains, to all appearance an incohering mixture of the same materials that form the rock itself. The more calcareous beds have not unfrequently some resemblance to some of the thin oolitic strata of England, in consequence chiefly of the *granular form* of much of the carbonate of lime; together with the innumerable fragments of fossils which sometimes form almost half of the mass. Unless attentively observed, this rock will appear much more sandy than it actually is, owing to some of the carbonate of lime being in the shape of small round yellow grains, like those of sand. Occasionally, especially near the bottom of the stratum, where it adjoins the marl, it contains a sensible proportion of the green grains, sometimes in such abundance as to unfit it for being burnt

into lime, the potash and other ingredients of the green mineral serving to vitrify it and form a kind of slag.

LOCAL DETAILS.

Mannington.—The most southwestern spot at which this limestone appears, is east of Mannington Hill, about three miles from Salem. It occurs in the banks bordering the meadows of Mannington creek, on the farm of Miss Parrot, lying two or three feet beneath the surface. The stratum here is of a light yellowish colour, and consists of minute fragments of shells and other fossils in a chalky state, together with grains of quartzose sand, and a few granules of greensand, all invested by particles of carbonate of lime. The rock is in thinly bedded layers from three to five inches thick, accompanied by a calcareous sand, differing in no respect but in the absence of cohesion from the material of the limestone. This sand rests both above and between the more solid layers.

Analysis of the Limestone from the farm of Miss Parrot, near Mannington Hill, Salem county.

Description.—Colour, straw-yellow, granular, and subcrystaline; fossiliferous.

Composition.—In 100 parts:

Carbonate of lime, - -	81·35
Carbonate of Magnesia, -	1·95
Alumina and oxide of iron,	1·04
Insoluble matter, - -	14·64
Water and loss, - -	1·02
	100·00

On the farm of Mr. W. Petit, in the vicinity of Mannington Hill, the limestone displays itself in considerable thickness, the layers of the rock alternating with the calcareous sand as described above. This locality is about a mile and a half southwestward from the poor-house.

The following analysis exhibits the proportion of carbonate of lime in the limestone of this neighbourhood.

Analysis of the Upper Secondary Limestone of Woodnut Petit, Salem county.

Composition.—In 100 parts:

Carbonate of lime, -	77·80
Carbonate of magnesia, -	1·20
Alumina and oxide of iron,	1·80
Insoluble matter, - -	17·80
Water, - - - -	1·12
	99·72

This stratum is destined to prove of signal service to the agriculture of all the region adjacent to it; for lime is particularly useful upon lands destitute of calcareous matter, like some of the more sandy tracts of New Jersey. The lime from this rock in Salem, is growing rapidly into use. I would recommend—as promising to prove highly beneficial—the soft, friable, unconcreted parts of the stratum which lie between the solid layers, especially near the bottom of the formation. Being already in a pulverulent state, and composed chiefly of carbonate of lime, with occasionally some of the grains of the green marl, the whole must constitute a *calcareous marl*, admirably adapted to ameliorate the lands of the surrounding country.

Both the *limestone* and the *calcareous sand* occur well developed on the farm of Mr. J. Ridgeway, near Mannington Hill. The rock at this place has a subcrystalline texture, being tolerably well cemented; towards the centre of the layers it is of a bluish colour. It is quarried to some extent and burned on the spot, yielding a very good lime. The price of this lime is about nine cents per bushel. The calcareous sand of this place is also growing into demand as a marl, and is vended at the rate of twelve and a half cents per load.

Analysis of Limestone from the farm of Hazleton Stacy, Salem county.

Description.—Colour, straw-yellow, compact, subcrystalline, and granular; consists largely of the fragments of fossils.

Composition.—In 100 parts:

Carbonate of lime, - -	75·56
Carbonate of magnesia, -	1·20
Alumina and oxide of iron,	2·50
Insoluble matter, - -	18·49
Water, - - - -	2·00
	99·75

Salem Creek east of Woodstown.—To the southeast of Woodstown, upon Salem creek, the limestone is visible in two or three places, though rather deeply covered by diluvial sand. I cannot learn that it has attracted attention or been burned for lime. It seems to be of very local extent, though possibly the main portion of the stratum has not yet been exposed.

Near Mullica Hill.—The limestone is found on the small tributaries of Raccoon creek, at two places about a mile and a half southwest of Mullica Hill. Though not as highly calcareous as that near Mannington Hill, it effervesces actively with an acid, and contains a moderate proportion of shells, in a fragmentary condition. It occurs in flat thin layers, separated by more or less of the calcareous sand. Its total thickness has not been ascertained, the stratum having been quarried to a very limited extent for the purpose of procuring lime. By selecting the more compact and crystalline portions of this rock, and observing proper precautions in the burning, it affords a very good lime, for agricultural purposes. This material is exposed in the banks of a meadow on Raccoon creek, on the farm of Charles Batten, where it shows the following beds:

1. Dark micaceous earth, thickness variable.		
2. Similar bed, abounding in fragments of white friable shells, - - - - - - -	1 ft.	6 in.
3. Soft, porous, fossiliferous *limestone*, - - -	0	4
4. Calcareous sand, with shells, - - -	0	10
5. Gray, compact, subcrystalline limestone, -	1	0
6. Calcareous sand, - - - - - -	2	6
7. Hard subcrystalline limestone only penetrated to the depth of eight inches, it is probably considerably thicker, - - - - - -	0	8

The more compact bands of the limestone afford a very good lime.

Near Barnsboro.—Two miles and a half east of Barnsboro, the calcareous stratum occurs near Mantua creek, on the farm of Josiah Heritage. The layers of the rock are between six and eight inches thick. It consists chiefly of comminuted fragments of shells and other fossils, and scattered grains of ordinary siliceous sand, and a few granules of greensand. It is a gray limestone, the interior of the mass having some degree of compactness, and promises with care in the calcination, to yield a lime fit for the purposes of the agriculturist.

Analysis of the Limestone overlying the Marl on the farm of Josiah Heritage, near Blackwoodstown, Gloucester county.

Description.—Yellowish-gray, granular, and subcrystalline, and very fossiliferous.

Composition.—In 100 parts:

Carbonate of lime, -	75·0
Carbonate of magnesia, -	1·8
Alumina and oxide of iron,	2·5
Insoluble matter, - -	18·7
Water, - - - -	1·7
	99·7

Near Blackwoodstown.—Upon the southern branch of Timber creek, the limestone is again met with south of Blackwoodstown. As in the other localities above mentioned, its thin layers are divided by more or less calcareous sand, a bed of which also overlies it at this place. The relative order of the beds commencing with the diluvium, and extending to the surface of the greensand stratum, is as follows:

1. Diluvial sand and gravel, - - - - 3 feet.
2. Yellow ferruginous sand, - - - - 1 "
3. Dark ferruginous clay, very tough, - - - 1 "
4. Gray siliceo-calcareous sand, containing fossils similar to those of the underlying limestone, 2 "
5. Yellowish-gray limestone, in thin irregular flaggy layers, contains several species of shells, and the *eschara digitata* in considerable abundance, 2½ "
6. Greensand marl, at the level of the stream.

Clementon.—In the vicinity of Clementon, on the north branch of Timber creek, the limestone shows itself in several places, occurring in thin horizontal bands, about six inches in thickness, imbedded between layers of the calcareous sand. These layers are some of them two and a half feet thick, furnishing an abundance of excellent calcareous marl, which is used to a small amount in the neighbourhood, and with striking benefit to the crops. The limestone itself is quarried and converted into lime. The upper surface of the stratum is about twenty-five feet above the level of the stream, and is overlaid by about five feet of diluvial matter.

The stratification here presents a somewhat singular anomaly, the calcareous sand forming in some places tall narrow cones or eminences, rising almost through the overlying stratum, which fills the intervals between them. Some of these cones are *four feet* high and two or three feet in diameter.

Analysis of the Limestone from the Farm of Mr. Isaac Thompson, near Clementon, Gloucester County.

Composition.—In 100 parts:

Carbonate of lime, - -	77·0
Carbonate of magnesia, -	1·5
Alumina and oxide of iron,	2·0
Insoluble matter, - -	18·0
Water, - - - -	1·0
	99·5

The fossils in this limestone are some of them very beautiful and in high preservation. Among them occurs the species *Eschara digitata*, in vast quantities; also, *Spatangus parastatus*, *Ananchytes cinctus*, and *A. fimbriatus*, and an echinus; besides *Anthophyllum Atlanticum*, *Scalaria annulata*, *Gryphea convexa*, *G. Vomer*, *Flustra sagena*, and teredo; together with several more zoophytes and shells.

Medford.—At Charles Haines's mill, two miles below Medford, on the creek, a section is seen exhibiting on the top a greenish siliceous sand; beneath this, a gray sand some feet thick, contain-

re beds have been cut through, in digging a well into the and stratum underneath. The limestone was reached, en seven and eight feet below the surface. It was in thin lar beds, separated by incohering sand and calcareous , similar to the mixture which composes the rock; its total ess is about six feet; the organic remains are the same characterize the limestone at Vincentown.

limestone belt measured from northwest to southeast, s as far as exposed to be about one mile wide, and there etty good reasons for concluding that it expands still more southeast.

centown.—The thin limestone stratum of the vicinity of ntown extends to the northeast, as far as Benjamin Pea- , on the road between Vincentown and Pemberton, and ile from the limekiln, on the south branch of the Rancocus. e southwest it extends between Vincentown and Medford, s seen on the farm of James Lippincott. It occurs at Moore's, on the Red Lion road, three and a half miles Lumberton.

o not think it at all established that Benjamin Peacock's is xtreme northeastern limit of this formation, for there is a and of calcareous rock in the marl bank at New Egypt, is almost identical in character with the rock at the lime- n the Rancocus; and what is remarkable, the top bed at is identical with the top or overlying bed at the limekiln, a thin laver of a *brownish siliceous sand*, tinged here and

Analysis of the Yellow Limestone, from the neighbourhood of Eayrstown, Burlington County.

Lime, - - - - -	49·69
Carbonic acid, - -	38·31
Silica and other impurities,	9·00
Water, - - - -	3·00
	100·00

It is in many places a very pure limestone, containing ninety per cent. of carbonate of lime. It has a structure somewhat resembling certain varieties of the *oolite* of Europe, imparting to it a granular and sandy aspect, which might lead the careless observer to regard it as a more impure limestone than it is.

SECTION IV.

Ferruginous Yellow Sand—Formation IV. Brown Sandstone and Conglomerate—Formation V.

Geographical Range and Extent of the Yellow Ferruginous Sand.—This formation occurs immediately above the greensand, unless where the thin fossiliferous limestone intervenes, and directly beneath the brown sandstone. Its position is usually at the base and in the sides of the outlying hills capped by the sandstone, and it probably spreads extensively to the southeast of the marl region in the district called "the pines."

Geographical Extent and Composition of the Brown Sandstone.—The circumstances under which this stratum occurs, have in the general way been already mentioned. *The brown sandstone* is found high upon the sides, or crowning the tops of all the insulated hills scattered over this district of the State; it lies in masses of all dimensions, from considerable blocks to pebbles the size of gravel, strewing the adjacent portions of the plain, and constituting in fact, in its disintegrated state, an essential part of the surface matter of the district. Being the only native material of the nature of building stone, known or employed throughout the lower section of the State, it becomes a matter of interest to

ıcertain and trace its numerous detached beds, so as to repre-
nt their place and extent upon the map. It is obvious that the
pography of the map of the State is not sufficiently minute for
ıch a purpose; and it is equally manifest, that the task, however
ıeful, would far exceed the scope and time allotted to this
ıneral survey. Though I am not able therefore to specify all
e localities of this rock, which indeed are very numerous, it
ay be useful to mention that the higher the ground the more
ıely we are to find it in mass, and that it is by no means con-
ıed to the distinctly formed hills, but occurs extensively in the
ore elevated parts of the intermediate country. We may state,
oreover, that the larger and *more angular* are the loose frag-
ents scattered around, the greater is the probability, that the
ıck exists in a solid stratum near at hand. The rock consists
two varieties, the one a coarse sandstone, the grains of quartz
ing cemented by brown oxide of iron, which colours the
hole mass; and the other a similar sandstone, containing in
ldition, small white or yellowish pebbles of quartz, giving it the
ıaracter of a puddingstone. In many instances, I have found
e finer grained variety to lie beneath the other, but whether
is be a universal rule or not, I cannot say.

The most conspicuous of the detached hills containing the two
rruginous strata before us, are:

The Nevesink range, on the southern shore of Sandy Hook
ıy; the range south and southeast of Middletown; the two
olated hills near Red Bank; those near Colt's Neck; the Sand
ills, between New Brunswick and Kingston; Mount Holly;
rney's Mount, near Juliustown; the Evesham Mount; the hill
the mouth of Shark river; and the Forked River Hills, near
arnagat.

Besides these localities there are several others where the
own sandstone, the uppermost of the series, occurs at an eleva-
on but little exceeding that of the general surface of the district.
ne of these points is about four miles from Burlington, on the
ad to Mount Holly.

The ordinary condition of the yellow ferruginous sand is that
a loose, dry, and rather coarse sand, deeply stained by the
ydrated peroxide of iron. This ingredient is sufficiently abun-
ınt in some places to act as a cement to the sand, and to form

large masses or concretions of a singular ferruginous sandstone of a cellular structure. These occur in many places in the cliffs of the Highlands of Nevesink, especially at their southeast extremity. In the cliffs near the mouth of the Nevesink river the ferruginous sands contain also numerous hollow concretions composed of the same brown mixture of sand and oxide of iron, having the shape of bottles, flasks, and hollow balls or bombs; and what is curious, these are full of white sand, the ferruginous particles seeming to have been withdrawn from the sand within, during the formation of this concretion.

The nearly uniform height at which the yellow ferruginous sand and the overlying brown sandstone occur, wherever they are found in the greensand region and the tract bounding it on the northwest, leads us to infer, that these beds were once continuous over the whole area at present occupied by the lower members of the series.

The denuding currents, which have removed so much of these materials from the surface of the marl tract, have, in their progress towards the ocean, deposited apparently a large portion of the looser particles, in a general diluvial covering, concealing the strata, throughout the whole southeastern side of the southern half of the State.

The superficial sands thus derived occupy the area generally known as *the Pines*. Constituting as they do the debris of strata remarkable for their ferruginous composition, we can readily account for the extensive deposits of *bog iron ore*, which they furnish wherever circumstances favour a sufficient infiltration of water through them.

ORGANIC REMAINS OF THE UPPER SECONDARY STRATA.

It is of little importance to the practical purposes of the present report, to enter into any details respecting the numerous highly curious fossils which abound in the formations, a general description of which I have now given. The most fossiliferous beds are the greensand or marl stratum and the limestone, which so generally reposes immediately upon it. The fossils from these deposits, together with others from some equivalent formations in the Southern States, are described with the requisite details in an

sting work devoted expressly to the subject, by Dr. S. G. on, of Philadelphia. This highly esteemed contribution to eology, is entitled "Synopsis of the Organic Remains of the ceous Group of the United States,"—1834.

that source I must refer for much specific information cting the individual fossils of the greensand group. I may lowed, however, to indulge in a few generalizations calcu- to impart more correct notions than commonly prevail cting the nature of the fossils, and the relative age and origin strata in which they are imbedded.

ere have been found up to the present time, in the marl and eposits connected with it, relics of about seventy-five extinct es, chiefly marine; of these, at least seven are of the class rge reptiles, including three species of *crocodile;* two of *;* a *tortoise,* and a wading bird; upwards of sixty-five are ins of shell-fish, corals, and other tribes low in the scale of nised beings. It is a curious fact, that *not one* of the fossils is catalogue can be traced to belong to any species living in resent day; and it is a scarcely less interesting circumstance between these fossils and the organic remains of the most ly related strata of Europe we discover but one species, *ecten Quinquecostatus,* common to the deposits of both con- ts.

he first fact determines the place of the marl group to be where among the secondary rocks, and the generic affinities e fossils to well known fossils of the greensand and chalk ations of Europe, makes us naturally regard that part of the ndary series as the most probable place to which to refer . The striking want of identity between the species, renders wever, a question of much uncertainty, to what precise for- on of the secondary series of Europe these deposits strictly espond.

o refer the production of the marl strata of New Jersey to ame period which produced the greensand rocks of Europe, ly in consequence of their both containing the green granu- ineral, and to their having, moreover, a general resemblance eir fossils, is to commit the decision of the question to far too a mode of reasoning. Received principles of geological stigation require us rather to consider our own deposits as

having originated during a somewhat different epoch from that which produced the European greensand formation.

The following list embraces nearly all the organic remains of the *upper secondary series*, hitherto discovered in New Jersey. It is compiled principally from the *synopsis* of Dr. Morton.

ORGANIC REMAINS OF THE GREENSAND FORMATION.

Reptiles.

Mosasaurus.—Teeth, vertebra, and bones of the extremities of this large massive saurian, have been found at various points in the greensand tract, in the excavations made for marl. They are thought to be identical with those of the Mosasaurus of Europe.

Geosaurus.—Teeth, with a portion of the jaw.

Crocodile.—Teeth and other portions, indicating three species, occur in the greensand.

Saurodon, (*Hays*).—Portions of a jaw of an extinct animal; the relations of which are not very clearly known. It is thought to be analogous to the saurians.

Great saurian, (of *Honfleur*).—I have discovered two vertebræ in the greensand near Big Timber creek, which I regard as either identical with, or very closely allied to bones figured by Cuvier from Honfleur, which he considers to approach nearer to the *plesiosaurus* than to any other genus.

Testudo.—Several bones of a large species of the order *Testudo*.

Coprolites.—These bodies have been occasionally met with, especially in the neighbourhood of Crosswick's creek, near the top of the stratum. In the present instance, they are most probably the fossilized dung of a species of crocodile; some of the bones and teeth of which occur near them.

Fishes.

Squalus.—Teeth and vertebræ of several species, considered formerly to belong to the genus *Squalus*, but lately placed by Agassiz under genera only more or less allied to the shark, are abundant in nearly every part of the greensand formation.

Sphyrœna.—Part of a jaw and several teeth of this curious genus of fishes have been found in the greensand, in Monmouth county.

Birds.

Scalopax (Snipe).—A solitary tibia, apparently belonging to this genus, has been found in the greensand, near Arneytown.

Testacea.

Sepia.—Several remains supposed to be of this genus.
Nautilus Dekayi, (*M.*)
Belemmites Americanus, (*M.*)
Ambiguous, (*M.*)
Ammonites placenta, (*Dekay.*)
Delawarensis, (*M.*)—Chesapeake and Delaware canal.
Vanuxemi, (*M.*)—Chesapeake and Delaware canal.
Scaphites hippocrepis.
reniformis, (*M.*)
Baculites ovatus, (*Say.*)
Bulla lignaria?
Turritella vertebroides, (*M.*)
encrinoides.
Rostellaria arenarum, (*M.*)
undetermined, (*M.*)—Casts, Delaware.
Tornitella bullata, (*M.*)
A small species; casts only found.
Cypræa.—A solitary cast, Delaware.
Patella tentorium, (*M.*)—Arneytown.
Ostrea falcata, (*M.*)—An abundant fossil.
plumosa, (*M.*)—Arneytown.
panda, (*M.*)—Delaware.
torosa, (*M.*)—Mullica Hill.
Gryphea convexa, (*M.*)
matabilis, (*M.*)
vomer, (*M.*)
Exogyra costata, (*Say.*)
Pecten quinquecostatus, (*Sowerby.*)
craticula, (*M.*)—Arneytown.
venustus, (*M.*)
Plagiostoma gregale, (*M.*)—Burlington county.
pelagicum; (*M.*)
Anomia argentaria, (*M.*)—Delaware.
tellinoides, (*M.*)

Placuna scabra, (*M.*)
Plicatula urticosa, (*M.*)
Avicula laripes, (*M.*)
A cast; species undetermined, (*M.*)
Pinna.—Two species not determined, (*M.*)
Pectunculus.—Species undetermined, (*M.*)
Cucullæa vulgaris, (*M.*)
antrosa, (*M.*)
Nucula.—Small casts of an unknown species, (*M.*)
Trigonia thoracica, (*M.*)
Cardium.—Apparently two species.
Cardita? decisa, (*M.*)—Delaware.
Crassatella vadosa, (*M.*)
tellini, (*M.*)
Venilia Conradi, (*M.*)—Arneytown.
Cytherea excavata, (*M.*)—Arneytown.
Lutraria?
Pholodomya occidentalis, (*M.*)—Delaware.
Pholas cithara, (*M.*)—Monmouth county.
Teredo tibialis, (*M.*)
Clavagella armata, (*M.*)—Arneytown.
Terebratula Harlani, (*M.*)—New Egypt.
fragilis, (*M.*)—New Egypt.
Sayi, (*M.*)—Burlington county.
Serpula barbata, (*M.*)—Deal, Monmouth county.
Hamulus onyx, (*M.*)

CRUSTACEA.

Astacus.—A small species, Delaware.
Cancer.—Fragments of several distinct species have been found.

ECHINODERMATA.

Clypeaster florealis, (*M.*)—Delaware.
geometricus, (*M.*)—Delaware.
Spatangus ungula, (*M.*)—Delaware.
Turbinolia inauris, (*M.*)

LOCAL DETAILS OF THE GEOLOGY OF THE MARL REGION.

With a view to exhibit the various aspects which the greensand assumes in different neighbourhoods, and to bring forward many

matters of local interest not appropriate in a general account of the formation, I shall here introduce a series of descriptions embracing the principal localities where the marl is at present excavated.

Pursuing the usual order adopted, in tracing the local features of the other formations of the State, that is to say, proceeding from the northeast towards the southwest, I shall commence with the township of Middlesex, in Monmouth county.

Middletown Point.—The lowest portion of the greensand stratum, where it passes into the underlying blue sandy clay, is exposed at several places in the vicinity of Middletown Point, which is a little outside of the boundary designated as the northwestern edge of the formation. The proportion of the green granular mineral in the marl of this neighbourhood, is, therefore, less than where the higher layers of the greensand are most developed, towards the southeast.

On the farm of *Mr. William Little*, not far from Middletown Point, the stratum is of a light ash-gray colour, inclining somewhat to greenish. Though it contains a large excess of clayey matter, the green granules are readily discoverable. These particles after separation from the marl by washing, are of a light clear green.

The composition of this marl is, in 100 parts:

Greensand, - - -	46·73
Clay, - - - -	53·27
Quartzose sand, - -	none.
	100·00

Assuming the proportion of the *potash* in the green grains to be 11·5 per cent., which is the mean of the fifteen systematic analyses given in a preceding chapter, we find the amount of the alkali in this marl to be 7·47 per cent., a quantity capable of imparting very decided fertilizing effects.

Mount Pleasant.—One of the most northern points where the stratum is dug for marl, is upon a farm of J. Morgan, near Mount Pleasant. In the same neighbourhood a marl of very similar quality, is found underlying a part of the farm of Mr. Castlereagh, near the northwestern base of the belt of hills lying south

of Middletown. These localities being near the northwestern margin of the formation, where only the lower portion of the greensand, adjacent to the underlying blue clay exists, the material contains, as in nearly every similar locality, but a moderate proportion of the green granular mineral, in which, as we conceive, the chief fertilizing power resides.

The hills here referred to, terminating on the farm of Mr. Conover, near the Dutch Church, consist of the ferruginous yellow sands, immediately overlying the greensand, overlaid by the brown ferruginous conglomerate which constitutes their summits. Greensand, therefore, occurs in places, beneath these hills and around their base. It is generally replete in the green mineral, and is of excellent quality, having been used in the neighbourhood since the first discovery of its fertilizing effects.

At Conover's, near the Dutch Church, we are in the midst of a highly fertile marl tract. The country is rather flat, or gently undulating, and extensively intersected by shallow valleys of denudation, or by meadows which are furrowed out down to the marl stratum, and in some cases twelve feet into it.

Analysis of the Marl, from the farm of Jacob Conover, Freehold township, Monmouth county.

Composition.—In 100 parts:

Greensand, - - -	85
Clay, - - - -	11
Quartzose sand, - - -	4
	100

The amount of *potash* which this marl contains, deducing it from that of the greensand, is 9·7 per cent.

The soil is mostly a loamy clay, sometimes sandy, and not often more than thirty feet above the top of the marl. Upon the marl lies a sandy stratum, containing a trifling share of the green particles and much ferruginous matter, which in some cases, by filtering down, has produced a change on the upper part of the marl bed to the depth of a few feet, dissolving out the shells and replacing them by oxide of iron. The thickness of the marl bed is not known, but perforations twenty feet deep have not penetrated through it. Its general aspect when moist is a deep blue,

or black; when dry a light blue, or gray. The lighter kind contains more clay, which is of a dove-colour, and sometimes of a light gray. The tint of the grains is a dark olive-green, almost black, and in this quarter rarely a light green. Sometimes the clay exceeds in quantity the green grains, and this in marls which are regarded as being very active. Those varieties which possess the lowest reputation are found invariably to contain either a quantity of siliceous sand or mica.

The fossils are Exogyra costata, Gryphea convexa, G. mutabilis, Ostrea falcata, Belemnites Americanus, Terebratula, Spines of Cidaris, Teeth of Shark, and Vertebræ of Crocodile.

When the marl dries, the surface is sometimes covered with a white or gray incrustation. When moist, the black marl often exhales a sulphurous odour, and the white efflorescence has an astringent sweetish taste, indicating it to be in part at least, a *sulphate of alumina.*

The marl in this quarter has been known and used as a fertilizing agent for forty years. It is applied very profusely; one hundred loads to the acre, or even more, being no unusual dressing. The improvement to the soil is very permanent, changing the natural growth from *Indian grass* and *five finger*, (or cinquefoil,) to fine white clover. *White alder* and other plants of rich soils abound in the meadows.

The natural *timber* of this, as of most other parts of the marl tract, consists of several varieties of Oak, also Chestnut, Locust, Beech, Maple, Dogwood, Hickory, Liriodendron or Tulip Poplar, &c.

The following analyses exhibit the composition of the marl in this vicinity:

Analysis of a Marl, (the upper stratum,) from the farm of John Smock, Freehold township, Monmouth county.

Composition.—In 100 parts:

Greensand, - - -	90·00
Coarse siliceous sand, -	2·00
Ash-coloured clay, - -	8·00
	100·00

Analysis of the Greensand.

Composition.—In 100 parts:

Silica, - - - .	51·00
Protox. Iron, - - -	25·10
Alumina, - - -	7·50
Potash, - - - -	9·30
Lime, - - - -	a trace.
Water, - - - -	6·50
	99·40

Marl from the farm of Dr. Conover Thompson, two and a half miles northwest of Freehold, on the head waters of South river.

Description.—Colour, light-gray, with a very little tinge of green; is adhesive, and has much the character of clay.

Composition.—In 100 parts:

Greensand, - - -	50
Clay, - - - -	40
Quartzose sand, - - -	10
	100

The proportion of *potash* in this marl, deduced from that in the greensand, is 5·7 per cent.

Marl from the farm of William T. Sutpham, on the head branches of South river, two and a half miles northwest of Freehold.

Description.—Colour, earthy-gray, with but little tinge of green, mottled and coloured with oxide of iron.

Composition.—In 100 parts:

Greensand, - - -	40
Clay, - - - -	52
Quartzose, - - - -	8
	100

The *potash* in this marl, deduced from that of the greensand, is 4·6 per cent.

Mr. Joseph Vandeveer has opened pretty extensive pits, about half a mile to the north and west of Bucks. The marl is much

ke that of Mr. Smock's. The following analyses will show the composition in 100 parts, of the upper and lower strata, the last of which is the best.

Upper stratum:

Greensand, - - -	70
Clay, - - - -	27
Quartzose sand, - - -	3
	100

Lower stratum:

Greensand, - - - -	92
Clay, - - - -	5
Quartzose sand, - - -	3
	100

The amount of *potash*, as deduced from that of the greensand, is, in the upper bed, 8 per cent., in the lower 10·5. The washed grains of the above marl are of a rich green, and small in size.

Large excavations have been made to the north and east of Bucks, by Mr. Charles Hendrickson, and a marl obtained corresponding in character to the preceding.

The above specimens furnish fair examples of the character of the marl in the vicinity of Swimming river.

Few exposures of marl are noticed in the tract between Bucks and Bloomdel. One and a half miles west from the latter place, it has been quite extensively worked by Elisha Holmes and Mr. Ely. A specimen taken at a point one-fourth of a mile from Bloomdel, where the road approaches to the side of Swimming river, will furnish an example of the marl of this neighbourhood.

This marl is greenish-brown in colour, and somewhat argillaceous in texture. When washed, its granules become more distinctly green, they are of small dimensions.

Composition.—In 100 parts:

Greensand, - - -	83
Clay, - - - -	13
Quartzose sand, - - -	04
	100

By direct analysis, this marl yields 8·5 per cent. *potash.*

At *Ely's mill* the marl is very impure, being almost entirely composed of siliceous sand; and doubts may exist whether it belongs to the marl bed, or the overlying clay.

At Mr. John Johnson's, *Nut Swamp*, the marl consists, towards the top, of the usual ferruginous yellow clayey bed, containing a small portion of the dark grains. This is not used, but is pared off to a depth of two or three feet. Next to this comes the dark marl, nearly black when wet, and rather hard in the bed, from the quantity of ferruginous matter which cements it. It crumbles on exposure, and becomes gray or even white, from the efflorescence which collects upon it. In it are large roundish masses of the marl cemented into firm stone by the oxide of iron. These, however, crumble down in time by exposure. In these beds the siliceous sand is very little in quantity. The top of the bed is the richest in greensand; lower down there is more of the dove-coloured clay, resembling precisely the clayey marl at Conover's. The vertebræ of a species of crocodile have been found here.

On *Porricy brook*, upon the road to Middletown, there occurs a fine exposure of the marl. It seems to be very thick and is covered by the yellow ferruginous sandy marl which is seen again half a mile south of Middletown, in the meadows. The black marl lies beneath.

At *Middletown* and its immediate vicinity, the upper yellowish, or ferruginous bed is chiefly seen; while the greensand marl has been reached in only a few points, though there can be no doubt of its existence at a small depth every where in the neighbourhood.

This upper portion of the marl stratum contains a considerable amount of the green grains, but mixed with much ferruginous clay and sand of an orange and variegated yellow hue. This orange and many-coloured clay is distributed in streaks and blotches.

The upper stratum is inferior to the green marl in fertilizing power, though it is used with excellent effect in many places near Middletown.

Marl from the Farm of Captain Edward Taylor, at Middletown.

Description.—Colour dull green; texture clayey, grains of small size. After being washed and freed from clay, the colour is more distinctly green.

Composition.—In 100 parts.

Greensand, - - -	80
Clay, - - - -	14
Quartzose sand, - -	6
	100

The proportion of the *potash*, ascertained by direct experiment, is 8 per cent.

The marl from the lower portion of the bed at Captain Taylor's, is richer in greensand than that from the upper, as will be seen by the following analysis:

Composition.—In 100 parts:

Greensand, - - -	90
Clay, - - - -	5
Quartzose sand, - -	5
	100

The amount of *potash* which it contains, is 9.9 per cent.

Between Middletown and Chapel, Jonathan Tunis has penetrated into the lower greensand marl, and uses it in preference to the yellow top bed, and with great advantage to the crop.

Near to Chapel, and about two miles east of Middletown, Mr. Daniel G. Conover, after penetrating the overlying soil and ferruginous layer, has obtained a marl of a singular mottled appearance; consisting of a mixture of light-coloured clay and greensand, looking when freshly cut somewhat like a decomposing granite. The lower portion of this marl has for its

Composition.—In 100 parts:

Greensand, - - -	84
Clay, - - - -	10
Quartzose sand, - -	6
	100

The proportion of *potash* deduced from that of the greensand, is 9·6 per cent.

The colour of the green mineral, after washing, is but little changed.

The upper portion of the marl bed of Mr. Conover is less valuable in greensand, as will be seen by the following analysis:

Composition.—In 100 parts:

Greensand, - - -	67
Clay, - - - -	30
Quartzose sand, - -	3
	100

The amount of *potash* which it contains, is 7·3 per cent.

Chapel is upon a flat hill or table land; and a well near this place dug seventy-four feet through the upper strata, did not reach the marl, though it shows itself, near the surface, in all the surrounding low grounds, where it is of very good quality.

The hills are sandy and strewed with fragments of the conglomerate, which is also in place, being quarried half a mile south of Chapel.

The timber growth on the hills contains a pretty large mixture of cedar.

The marl extends from Chapel north towards the Bay shore, as far as the permanent land itself. Richard Wallin has reached it in digging a well; it was seven feet below the surface, and was penetrated fourteen feet. Mr. Anderson, within half a mile of the shore, also has a marl pit. The dark green grains abound in the sands of the beach, and every where as we pass along the road from Chapel to the Bay shore, towards the east.

Bay Shore and Cliffs of Nevesink Hills.—The marl appears to extend to within a short distance of the Bay shore near Compton creek. The first cliffs which we meet with on going along the shore to the east, exhibit a dark stratum, chiefly clay and siliceous sand, with mica, containing very little of the marl, and often a considerable share of copperas, which shows itself upon the surface, in the state of a yellow efflorescence. Tracing the base of the cliffs, we see this stratum slowly rising and forming the lowest bed visible along the beach, nearly the whole way to the termination of the highlands at the Telegraph hill.

In some places the cliffs have a height of fifty or sixty feet,

mposed of several different beds, all containing more or less of
e marl; but some of the layers are chiefly made up of siliceous
nd, and clay, and ferruginous matter. Over the dark lead-co-
ured siliceous clay, a stratum of the sand is seen, often green,
ough for the most part gray and quartzose. High above this
e true marl is seen in many places, and may be known by its
ite efflorescence.

The marl taken from the cliffs about two miles northwest of Telegraph Tavern, exhibits the following,

Composition.—In 100 parts:

Greensand, - - -	92·2
Clay, - - - -	5·8
Quartzose sand, - -	2·0
	100

The proportion of *potash*, deduced from that of the greensand, 0·6 per cent. The appearance of this marl is a dull or dirty en, and is little changed by washing.

Where the cliffs are high, the conglomerate is seen in its natu- place, over the top of all. Near the upper surface of the rl bed may be seen large globular masses of indurated and vented marl, like that found before at Not Swamp. They here ess the hardness of a true rock and do not crumble. The hly fractured surface is often very beautiful, showing the en grains of marl distributed through a cement of argillaceous oxide of iron. The globular masses are seen in horizontal ers in the marl, and they strew the beach pretty thickly. The cks of the horizontal iron stone are often several feet in meter. Sometimes the consolidated ferruginous masses of the vented sand are the size of a small apartment.

n several places beneath these cliffs of the Highlands, vast ses of the strata have subsided by the undermining action of water passing through the lower beds, and they form an *ler-cliff* or landslip with a steep pitch toward the land, bringing rn into nearer view the top strata, the upper ferruginous sands which, owing to the condition of their oxide of iron, are of a t beautiful reddish colour.

At the shore beneath the Telegraph hill on the ocean side, the

lower dark astringent stratum is seen at the water's edge, the piles in the foundation of the wharf, in front of the Telegraph Tavern being driven into it. Some portion of this bed is said to be marl, and the green grains abound every where *among the sands of the beach*, as they do at Long Branch, a few miles more to the south, and indeed the whole way from the commencement of the Nevesinks along the bay shore, and along the sea-shore to Deal.

Tracing the cliffs round the Telegraph Point to the mouth of the Nevesink river, the lower or marl-bearing strata, are covered by a steep talus or inclined bank of fallen matter at the base of the cliff, reaching thirty or forty feet up. Above, are the yellow sands covered by a layer of the cellular iron stone several feet in thickness, being beautifully displayed at the Devil's Chimney. Above this there is a very ferruginous, brownish, consolidated sandstone, full of impressions or casts of shells, especially *ostrea falcata*. It seems to be a more ferruginous portion of the stratum. A little above this, at the height of eighty or ninety feet, is a bed a few feet thick, of a bright *green clay*, consisting apparently of the same material as the light green variety of the marl, but not in a granular condition; it includes a few indistinct light green grains. Over this again and towards the top of the hill, the fragments of the conglomerate abound, and there is every reason to believe that all the hills near the mouth of Nevesink river, are capped by the conglomerate in place.

Along the north bank of the Nevesink river, at Mr. Hartshorn's, the stratum which is on a level with the beach is the copperas-bearing dark clay and sand. It has been found by him to be hurtful to the soil when applied thick, but as it contains a very considerable share of the green grains, it is probable that applied in lighter dressings, it might prove somewhat beneficial.

There is no good marl from the mouth of Nevesink river up as high as *Claypit creek*, above which as far as its head, the marl extends on the north side and is generally very good. The other or astringent stratum below the marl, sometimes takes its place in the banks on the water's edge.

Ascending the Nevesink river, no good marl occurs below the west side of Burgis's or Claypit creek, where it is of excellent quality; from thence to the next, or Redneck creek, the impure

astringent kind prevails; on the west of the creek, the bed at the water's edge is again the true marl, being like Burgis's. The deleterious bed contains much ordinary sand and mica, abounding also in oxide and sulphuret of iron, and seems to be in fact the same stratum as that upon the bay shore under the Greenland banks, in the Nevesinks.

We may trace the marl to Crow's creek; approaching which it becomes very green and good. Here and farther east it lies below the layer of nodular indurated marl seen on the bay shore, on the top of which is the micaceous sandy bed containing copperas. In one place on the very beach, the marl has been dug and exported to Barnegat, for sixty-eight cents for the load of twenty bushels.

On drying this marl, it assumes a light-green colour. The spurious bed almost invariably presents the yellow astringent efflorescence, and is evidently a different layer from the good marl; and there seems to be no good reason to doubt that this shore if examined, would every where display *both* beds; the astringent clay above, the nodules next, and below all, the pure greensand marl.

The reason that the banks of the Nevesink river display sometimes the true marl, and at others the dark astringent clay, seems to be, that there occurs a slight undulation of the strata. Some have thought them portions of the same stratum, shading into each other upon the same level. The above view is the correct one, and is important, as it indicates the possibility of reaching marl almost *any where* by sinking to a very small depth.

Red Bank.—In this neighbourhood the banks of the river vary in elevation from ten to twenty feet and upwards. On the north side, near the bridge, on the land of Mr. Tylee Conover, the bank presents a bed of diluvium four feet thick, the lower part of which is tinged with oxide of iron. Beneath this lies the upper layer of the marl, eight feet in thickness, consisting of a mixture of very tenacious clay and greensand. Resting directly below this, and nearly on a level with the tide, occurs the main bed of marl, forming the beach of the river. It is composed almost entirely of the greensand, the extraneous matter being merely a little white siliceous sand and clay. Excavations to the depth of several feet are made at the retiring of the tide, and the marl

thus procured is much preferred to that of the overlying layer in the bank. Its colour is a dirty green; that of the washed greensand is brighter; the granules are rather larger.

That portion of the stratum which is below the level of high water at Mr. Tylee Conover's, gives the following:

Composition.—In 100 parts:

Greensand, - - -	93·85
Clay, - - - -	6·15
Quartzose sand, - -	none.
	100·00

The amount of *potash* in the whole marl, as obtained by direct analysis, is 9.5 per cent. Though the marl throughout this neighbourhood is generally rich in the greensand, the good effects of this are sometimes impaired by the presence of decomposing sulphuret of iron, which it derives especially from the overlying ferruginous bed.

At Judge Patterson's we have a convincing proof of the hurtful influence of the copperas, in a marl otherwise excellent; his being extremely rich in the fertilizing green grains. The bank for a few feet up from the level of the water, is composed of the marl stratum, abounding in the yellow astringent efflorescence. Tried upon the land, it has been found injurious to the crops for at least the first year or two, unless when applied in great moderation.

Where the poisonous impurity is abundant, it is not safe to employ more than five loads of the marl upon an acre; nor do I see any good reason why five loads of a rich marl is not enough, in nearly all cases, for a single dressing.

The entire material of the beach beneath the bank, consists of the dark greensand, from which nearly the whole of the astringent matter appears to be removed by the washing of the waves, as the caving of the bank from time to time, brings down the matter upon the beach, and within the dissolving action of the water.

This washed marl is pure, and may be used, as some experiments made by Judge Patterson have fairly proved, in any proportion, even at the rate of one or two hundred loads to the acre,

without showing any caustic action upon the vegetation. This among other facts induces me to recommend to the farmers, to expose their *caustic* or astringent marls to the rain for a season, before attempting to employ them.

On the south side of the river, one-fourth of a mile below Red Bank, the shore, which is rather steep and about twenty-five feet high, displays a bed of dark micaceous sandy clay, overlaid by a mass of diluvial sand and gravel twelve feet in thickness—the line of separation between these being very obvious. The dark micaceous clay and sand on this side of the river seems to replace the upper impure layer of marl of the opposite or north shore. From the surface of the water to its upper edge it is about twelve feet in thickness, and it extends down along the water's side as far as Jeffries' Point.

The stratum of pure greensand lying immediately below this layer, corresponds to the lower bed on the north side of the river. It consists almost entirely of the green granules. The marl is penetrated to the depth of about twenty feet at several spots along the beach. Though Jeffries' Point seems to be the termination of the dark micaceous clay and the underlying greensand on the south side of the river, yet there are good reasons for inferring that the marl extends along the opposite side at an accessible level the whole way to the extremity of the peninsula dividing the Nevesink and Shrewsbury rivers.

The marl at Jeffries' Point is of a lighter green than any in this immediate quarter. Very few organic remains occur in the greensand formation in this vicinity, either in the cliffs of the Nevesink Hills or in the banks of the river.

The marl of Jeffries' Point gives by analysis the following:

Composition.—In 100 parts:

Greensand, - - -	92·5
Clay, - - - -	7·5
Quartzose sand, - -	none.
	100·0

The proportion of *potash* in this marl, deduced from the average quantity in the greensand, is 10 per cent.

When washed, the granules are large and of a dark green colour.

A marl taken from the beach near Red Bank, belonging to Jonathan M'Lane, exhibited the following

Composition.—In 100 parts:

Greensand, - - -	91·4
Clay, - - - -	8·6
Quartzose sand, - -	none.
	100·0

The *potash* in this marl, by calculation, is very nearly 10 per cent.

The ordinary aspect of the marl is a dull green; that of the washed greensand is a brighter, purer green. The granules are rather large.

Marl of good quality displays itself in several places between Red Bank and Shrewsbury, and around Eatontown. That at the farm of Mr. Lafetrea near Eatontown affords by analysis the following

Composition.—In 100 parts:

Greensand, - - -	79
Clay, - - - -	13
Quartzose sand, - -	8
	100

The *potash* in this marl, by estimation from the amount of the greensand, is 9.1 per cent.

About one mile southeast of Eatontown, in a low swampy tract of ground, Dr. John P. Lewis has uncovered a stratum of somewhat peculiar marl, composed of fragmentary shells, a little greensand, and much quartzose sand intermixed. From several trials which have been made, it would appear to be endowed with decidedly fertilizing properties.

Between Eatontown and Long Branch, and about three miles from the sea-shore and two from Eatontown, at a mill called Turtle Mill, there occurs a variety of marl somewhat analogous to the above. It consists of hardly any thing but shells in a fragmentary condition, very friable and purely calcareous, and contains but a very small share of the green particles; its colour

is yellowish, owing to a small portion of common sand. The shells are in a very broken condition, but we may recognise them to belong to the well known secondary fossils of the marl. The large shell called *Terebratula Harlani* seems to constitute a large portion of the mass. Something similar is seen farther to the south, on the farm of Mr. Field, about one and a half miles from Eatontown. This deposit deserves to be traced more minutely, as it is probably a new variety of marl fit for the agriculture of the neighbourhood, containing much more lime than the greensand formation usually possesses.

Long Branch.—Along the cliffs facing the ocean in front of the boarding-houses at Long Branch, appearances in several places show that the true marl stratum meets the sea-coast in this quarter, and that it cannot lie at any considerable depth below the beach. About half a mile north of Renshaw's, at apparently the highest point in the cliff, the astringent clay bed which so generally accompanies the marl as an overlying stratum is exposed, rising four or five feet above the average level of the beach. This itself is strongly indicative of the existence of the marl at no great distance beneath. The probability of this is manifested, however, in another way. The sand of the beach contains a very notable proportion, often *five per cent.* or more, of the green granules of the marl, which examination assures me cannot be derived from any of the strata in this part of the bank, and which therefore, can only come from a bed extending into the sea below the ocean level, or at least lying as low as the base of the cliff. This mixture of the green granules among the sand of the beach is observable along the whole of the bay shore, from near *Chapel* to the Telegraph Hill, and thence along the ocean side from the mouth of the Shrewsbury river past Long Branch to Deal, and somewhat further. It has been discovered somewhat recently, that the beach sand throughout this line is endowed with active fertilizing powers, attributed heretofore to salt and other supposed marine substances in the beach. But the well known properties of the green grains, coupled with the fact that in every place along the shore further south than Deal, where the marl does not reach the coast, the sand of the beach contains none of the dark granules, prove conclusively that the benefits so distinctly perceived, are attributable to the source which I suppose. The good

effects of the beach sand are strikingly exhibited upon Wardell's farm, a little north of Long Branch: no less decided results are also witnessed on the farm of Jacob Curlis, at Deal. The most sterile patches of sandy soil are made to yield very abundant crops of corn by the use of this powerful agent. The quantity of the beach sand applied, is often as great as two hundred loads to the acre; but the facilities for procuring and spreading it are very great. It is obviously a point of importance to discover those portions of the beach where the green matter is most abundant; for there are spots which are much darker than the rest from this cause. Experience has already taught that the sand gathered after the heavy storms of the winter, is the most efficient, a fact countenancing the notion that the green grains are cast up by the beating of the surf. The high degree of fertilizing power possessed by the beach sand, upon both the clayey and dry sandy soils of this portion of the sea-board, goes far towards establishing several very essential points in the doctrine previously advanced concerning the cause of the enriching qualities of the greensand. It clearly demonstrates, in the first place, that the efficacy of the marl lies mainly in these green granules, and not, as many imagine, in the shells and other foreign substances discovered occasionally in the bed. It moreover decides the point, that the more essential and permanent properties of this mineral are in no way connected with the gypsum, or with the carbonate of lime, which so frequently form a coating upon the green grains. Both of these incrusting matters, should they exist in the stratum from which the granules are derived, are too easily dissolved by the water which incessantly washes the shore, to remain in the sand in the smallest appreciable quantity.

We are forced, therefore, to ascribe the usefulness of the green mineral to its *potash*, the only ingredient of an alkaline action which is always present and which is essential to its composition.

Another important consideration is, that the marl or green mineral loses nothing of its potency by a long exposure, even of years, to water and the atmosphere; in other words, that it is not dissolved, or decomposed, or changed, by the ordinary atmospheric agents which react so powerfully upon many other minerals. We are to regard it, therefore, as nearly unchangeable until the roots of the plants come in contact with it, cause its decomposi-

tion, and by the *vital* powers of their organs, imbibe a portion of some of its constituents.

When we behold a luxuriant harvest, gathered from fields in which the original soil is of a kind least of all congenial to vegetation; when we find that all this fertility, contrasting so strikingly with the barrenness around it, proceeds from a few granules of a substance sparsely distributed through the enormous and counteracting excess of sea-beach sand, more arid than the soil to which it is applied, are we not led to look with admiration on the potent properties of this curiously constituted mineral? The developements of geology are full of instances like this, showing in how many unlooked-for ways, the mineral world may be made subservient to the good of mankind.

This striking proof of the fertilizing power of the marl ought to encourage those districts not directly within the tract, where some of the strata possess the green granules in a sensible proportion. It expands most materially the limits of the territory where marling may be attempted, and points us to many beds as fertilizing, which otherwise would be deemed wholly inefficacious.

There can be no doubt that the agriculture of our seaboard States is destined to derive essential benefit from the remarkably wide distribution of this green granular mineral under various geological relationships, besides those in which it presents itself in New Jersey.

Thus the tertiary shell marls of Delaware, Maryland, and Virginia, and I might add of other States still farther south, contain not unfrequently as high a per centage of the greensand, as does the sea-beach sand upon the coast of Monmouth county in New Jersey; and I may mention that my brother, Professor William B. Rogers, of the University of Virginia, charged with the geological survey of that State, has already done important service to the agriculture of some districts, by discovering, and calling attention to the existence of the greensand in the tertiary strata of Virginia.

Between Long Branch and Deal, the marl stratum has been penetrated thirty feet. The upper two feet consist of a green clay, seemingly derived from the disintegration of the green grains, intermixed with a large proportion of yellowish white clay. The main marl bed having a thickness of about twenty-six feet, contains several subordinate layers, but all contain a

large share of the green granules. Beneath the whole there is a gray-yellowish clay, in which the grains abound; they are remarkably large, and are associated with numerous casts of shells. A similar layer is seen in Jacob Curlis's pits, where it contains beautiful casts of the *nautilus* and several univalve shells, and also shark's teeth. The marl stratum, composed of nearly the same layer, is exposed again between Jacob Curlis's and the Whale Pond Mill, at John Curlis's. At all these points, the bed contains a considerable share of astringent matter, sulphate of iron, which, wherever it shows itself in excess, may be counteracted by following the suggestions proposed in this report.

Elisha West's, near Long Branch.—A very interesting and rather extensive exposure of the marl stratum may be seen on the farm of Elisha West, about one mile south of the boarding-houses at Long Branch, and in a direct line, not more than a fourth of a mile from the sea. The pit is dry, a rather unusual circumstance, and occurs near the head of a gently sloping hollow or small valley, which circumstance in connexion with the obvious outline of the ground between it and the shore, leads the observer to believe that the top of the stratum is not as low, by several feet, as the sea-beach. It follows, if this be correct, either that the marl bed runs horizontally and meets the cliffs at the sea-side, above their base, where the inclined pile of fallen matter may conceal it, or else that it descends with a gentle eastward dip until it merges beneath the ocean at a lower level than the tide. This question is of some consequence to the neighbourhood, for a good marl pit opened directly on the shore would benefit no inconsiderable line of coast.

The section in the pit is about twenty feet deep, being almost entirely in the marl stratum. The top layer, one foot thick, consists of an indurated marl, somewhat similar to that at the top of the marl at Ely's, on Shark river. It contains but a trivial proportion of the granules, which are imbedded in a paste of a grayish-white calcareous clay, identical in aspect and composition with certain waterworn rocky masses which strew the beach in front of the boarding-houses. This apparent identity in all respects except hardness, furnishes a farther proof that the marl stratum is prolonged to the sea-side, and rests either at the level of the beach or at so small a depth beneath the surface, as to be within the action of the surf, which may, I conceive, disturb

and bring to shore not only portions of this upper bed, but likewise of the softer marl below.

Beneath this upper bed in the pit at Elisha West's, there occurs a hard, somewhat firmly cemented mass, consisting of light green grains and a little ordinary sand, the whole being eight feet thick. In it is a very thin layer of white clay. Lower down we meet a gray and afterwards a yellowish ferruginous marl, both rather sandy, and in aggregate thickness about three feet.

Still lower and throughout the rest of the vertical section we find a layer of yellowish ferruginous sand, containing a very moderate proportion of the green grains. Few or no shells are visible in the perpendicular wall or section disclosed in this pit, but numerous traces of casts occur, showing that they have once been there, and intimating the nature of the change which they have undergone, and the possibility that they may have furnished to parts of the stratum a small amount of diffused carbonate of lime and perhaps gypsum.

The marl from the pit of Elisha West displays by analysis the following

Composition.—In 100 parts:

Greensand, - - - -	73·2
Clay, - - - -	22·8
Quartzose sand, - -	04·0
	100·0

The amount of *potash*, deduced from the above proportion of greensand is about 8·4 per cent.

This marl is a light yellowish green; adhesive; the admixed clay giving it a mottled appearance. The washed material is darker and more distinctly green; the granules are small.

Tinton Falls.—The stratum here is a dark brown and greenish friable sandstone, which forms a horizontal ledge across the creek, causing, by its abrupt termination, a sudden fall of about sixteen feet. It seems to be nothing more than a very sandy and highly ferruginous marl, consolidated by the cementing action of the oxide of iron into a moderately compact sandstone. It abounds in the usual characteristic shells of the marl series, but these are almost invariably in the state of casts. The amount of the green grains in the rock is not very considerable, though

sufficient, in some of the layers, to impart a decidedly green or dark olive hue to the otherwise brown mass. Three layers of nearly similar aspect, all differing somewhat in their hardness and the proportion of oxide of iron and of the green granules, are to be observed here.

Whether this rocky stratum at Tinton Falls may not be the equivalent of the brownish ferruginous sandstone with casts, which overlies the friable marl in the Nevesinks, near the mouth of Shrewsbury river, or whether it is the true marl stratum rather more than usually cemented, and ferruginous, are questions which it is of some importance to determine, in order to form a just opinion as to the probability of meeting, at a moderate depth, the valuable bed of loose greensand itself.

Nearly upon the same horizontal line with the top of this rock, and at a less distance than a fourth of a mile, a bed of sandy green marl, not consolidated, shows itself very near the surface of the fields upon the Monmouth road. The somewhat clayey texture and greenish hue of the road itself between this point and Eatontown, is strongly indicative of the proximity of the marl stratum to the soil.

Poplar Swamp.—At Jacob Woolley's, Poplar Swamp, the section of the marl stratum which is exposed, exhibits three separate layers. The top bed is about three feet thick; the granules are of a light green, and mixed with them, is a small quantity of common siliceous sand. The next, or middle layer, is four feet thick, of a much darker green; and the bottom bed is of a dull greenish ash colour, and contains rather less than fifty per cent. of the green granules, the rest being clay and ordinary sand. Very few shells occur at this locality, though bones of the fossil crocodile and shark's teeth are occasionally met with.

The middle stratum gives indications, from its darker green colour and greater freedom from foreign matter of being the most efficacious of the three as a marl. Astonishing results have been produced by it when applied in the proportion of from seven to ten loads to the acre.

This marl lies on Poplar Brook, the source of which is about a mile west of Mr. Woolley's, its entrance to the ocean being at Deal. There is marl in the banks of the meadows and adjacent ravines throughout nearly the whole length of the stream.

Voolley manured a piece of land in the proportion of two loads of good stable manure to the acre, applying upon :ent tract of the same soil his marl in the ratio of about loads per acre. The crops, which were timothy and were much heavier upon the section which had received l: and there was this additional fact greatly in favour of l manure over the putrescent one, that the soil was also *free from weeds*, while the stable manure had rendered its ıp very foul.

greensand stratum at Poplar Swamp seems to be almost free from any sulphate of iron or other astringent mate-l, as a consequence, the crops seem not to be scorched by ı dose, however lavishly applied.

ɔ. can be no doubt that twenty loads of marl per acre ɔ regarded as an unnecessarily bountiful dressing, but ng the relative cost of the two manures, when employed ıtio above stated, we find a considerable disparity in fa- the greensand. Placing the home value of farm-yard at one hundred cents for each two-horse load, and that of l at twenty-five cents per load, we have the expense of ıg one acre, *two hundred dollars;* of marling the same, *rs.*

being an *experiment*, an extravagantly large dressing of was employed, but not exceeding the usual average ap-ı more than the twenty loads of marl surpassed what was ry.

rience has already shown that land once amply marled its fertility with little diminution for at least ten or twelve f care be had not to crop it too severely; while with all ıble precautions, the stable manure must be renewed at ee times in that interval to maintain in the soil a corre-g degree of vigour.

from Mr. Woolley's middle bed possesses this

osition.—In 100 parts:

Greensand, - - -	86
Clay, - - - -	12
Quartzose sand, - -	2
	100

The amount of *potash* by experiment in this marl, is 7·5 per cent.

I present here the analysis of another marl from the same neighbourhood. It is that of Mr. John Howland, of Poplar Swamp. Its colour is grayish-green, owing to a coating of carbonate of lime on some of the particles. The washed material is a light and rather rich green.

Composition.—In 100 parts:

Greensand, - - - - - - -	88·5
Clay with a little carbonate of lime, -	6·5
Quartzose sand, - - - - - -	5·0
	100·0

The amount of *potash* deduced from that of the greensand, is 9·7 per cent.

Shark River.—Ely's marl pits, on Shark river, present the following layers in the descending series:

1st. A dark-brown or amber-coloured mixture of sand, clay, and mica; reminding one strongly, both from smell and aspect, of an ooze of the ocean. It sometimes contains thin seams of very coarse sand, completely water-worn and rounded. This bed is between seven and eight feet in thickness, and is seen resting immediately on an indurated or cemented marl. It is visible elsewhere in the neighbourhood, and always has the astringent character of the corresponding bluish sandy clay already so often mentioned, with which, in fact, I hold it to be identical as a stratum.

2d. A hard cemented marl, being a paste of a yellowish white clay, perhaps containing gypsum, with a moderate sprinkling of the marl grains. Except in its being a cemented mass it differs but little from the bed of friable marl which underlies it. It is two feet thick.

3d. This lower stratum yields the well known marl so much in request in this part of Monmouth. When moist, the mass possesses a dark, dull, grayish hue, from the colour of the clay which coats the granules. When dry the colour is a very dark plumbago (black-lead) tint, or sometimes a deep olive-green tinge. It consists of little else than the dark granules, the small quantity

of clay present occurring only as a thin coating upon the grains. The lower part of this layer has a more yellowish hue from a greater excess of the clay, which is here rather ferruginous. The thickness of the bed is not known, though it has been penetrated sixteen or seventeen feet.

I have witnessed its action on some very poor light soils, which were rendered highly fertile from the use of this marl in a first dressing of five loads to the acre, and an equal quantity at the next rotation of the crops.

The best marl of Ely's bed exhibits the following

Composition.—In 100 parts:

Greensand, - - -	80
Clay, - - - - -	20
Quartzose sand, - - -	none.
	100

The amount of *potash* in this marl, by calculation, is 9·2 per cent.

The following analysis shows the composition of another marl of this neighbourhood, that from the pit of Mr. John Shaft, of Shark river.

The specimen was taken from near the mill, and is the best of the several samples procured.

Composition.—In 100 parts:

Greensand, - - -	87
Clay, - - - - -	11
Quartzose sand, - - -	2
	100

The amount of *potash* ascertained by analysis, is 9.5 per cent.

Squankum.—Thorp's marl, near Squankum, presents the following varieties:

1st. On the top, a bed of diluvial sand and gravel, and in certain places a coarse, ferruginous sandstone, sometimes two feet thick.

2d. A light greenish-blue clay, the upper part of which sometimes shades into a brown sandy clay, like the corresponding bed at Shark river. One portion of this contains a small mixture of the green granules. This portion appears, in fact, to graduate

into the upper part of the marl bed, in which there is not unfrequently as much as fifty per cent. of the clay itself.

3d. The inferior layer is the true marl stratum, consisting of little else than the green granules. When dry, the colour of the mass is a tolerably light grayish green, but not uniform, light specks occurring throughout the marl.

When the heaps have dried, the external grains are coated, in some degree, with a white efflorescence. The upper portion of the bed, in consequence of containing much of the astringent clay, presents a good deal of the yellowish efflorescence ascribed to copperas. The depth which has been reached in the pits is about twenty feet, and hitherto the bottom of the marl has not been struck. The lower part of the stratum is conceived to contain the best marl. It is not free from decomposing sulphuret of iron, judging from the strong odour of sulphur which every pile of it exhales, and which it does not lose even after being conveyed to a distance, and long exposed to the weather. It probably, therefore, contains a slight impregnation of sulphate of iron or copperas, but not enough to injure it, if we are to infer from the reputation which this marl possesses.

At the pits, which are very extensive, the marl is sold at the rate of 37½ cents the load, the purchasers having to dig it. It is transported by wagons to a distance, in some directions, of twenty miles, and retailed, when hauled that far, at the rate of 10 or even 12½ cents per bushel, being very profitably spread upon the soil in the small proportion of twenty-five or even twenty bushels to the acre.

In its external aspect this marl does not differ from many others in the State, nor am I convinced that it surpasses a numerous list in point of efficacy as a fertilizing agent. The amount of *potash* which it contains is materially less than belongs to a large proportion of the better marls of the region.

Marl from the upper part of the bed at Squankum.

Composition.—In 100 parts:

Greensand, - - -	58·36
Clay, - - - -	27·64
Quartzose sand, - -	14·00
	100·00

The amount of *potash* in this marl, deduced from an analysis of the greensand of this locality, is 6·1 per cent.

Marl from the middle part of the bed at Squankum.

Composition.—In 100 parts:

Greensand, - - -	35·72
Clay, - - - -	54·28
Quartzose sand, - -	10·00
	100·00

The amount of *potash* in this marl, deduced from that of the greensand, is 3·7 per cent.

Marl from the lower part of the bed at Squankum.

Composition.—In 100 parts:

Greensand, - - -	68·29
Clay, - - - -	27·71
Quartzose sand, - -	4·00
	100·00

The amount of *potash* which this marl contains, derived from an analysis of the selected grains, is 7·1 per cent.

In the neighbourhood of Mount's Mills or Berkelue's, at Mr. Rue's, half a mile south of Spotswood, there is a black clay like that of Middletown Point, containing a considerable quantity of the marl. It has been thought to be somewhat beneficial to the land. It is near Mr. Berkelue's mill-pond, and not in the lowest ground. There is a considerable undulation of the surface in this quarter, though the denudation would seem not to have reached a low level. The superficial stratum is sandy, containing also some of the loose materials characteristic of the marl region.

At the pits of William Johnson, one mile east of the former, the supposed marl stratum exhibits a small proportion of the greensand with much siliceous sand, some clay and mica, and has a decidedly sulphurous odour; it also tastes of copperas,

and has a yellow crust. These pits lie in the side of a hill, on the road from the mills to Johnson's house. Around this neighbourhood the land is rather high, and hence perhaps the true marl has not yet been reached. The proximity of this impure marl to the railroad, makes it desirable, if possible, to learn whether the true greensand bed does not lie below it at an accessible depth.

Three miles from Englishtown, on the Matchaponix creek, at John Perrine's saw-mill, the same stratum is seen as at Rue's. It is not so destitute of the grains of marl as to be entirely unfit for use. It occupies the bed of the creek for some distance below the saw-mill. It is sandy and micaceous, with small irregular concretions of clay cemented by oxide of iron, and a few grains of marl.

In many parts of this section there is a stratum of a mottled bluish clay with blotches of yellow ferruginous clay. This lies over the spurious marl stratum, and looks not unlike the upper marl bed at Middletown and its vicinity.

Around the parsonage, two and a half miles from Englishtown, on the road to Freehold, the marl is pretty good, though a little impure from containing some sand and clay. At no great depth it contains shells and other fossils. The soil is sandy, but grows better to the northwest. All the indications of the marl region are present here.

In and around the farm of Mr. Hunt, one mile from Bloomsburg tavern, the marl lies extensively denuded in the meadows. It is pretty good, consisting mainly of greenish grains, with a good deal of clay. These meadows are very ferruginous, and contain bog iron ore.

Marl from the farm of Mr. Hunt.

Composition.—In 100 parts:

Greensand, - - -	75·0
Clay, - - - -	19·5
Quartzose sand, - -	5·5
	100·0

The proportion of *potash* which this marl contains, deduced from that in the greensand, is 8·6 per cent.

The marl seems not to be known much farther to the northwest, in which direction there is a low range of hills of denudation.

Below the dam at Bargain's mill, on the Millstone creek, the spurious marl stratum is visible again. At Lewis Perrine's, half way between this and the Presbyterian church, the marl is found, but not very good; it lies rather high in the fields. The true marl is known here as far west as Mr. Van's, two miles farther towards the railroad on Rocky brook, one mile below Imlay's mills. The quality is not known, but it is supposed to be the inferior sort.

At Willow Tavern or Clarksburg, a thin layer occurs in the roadside, being a light-green marl with yellow specks. Beneath this there is a whitish bed of siliceous sand with white clay and a very few yellow and green specks.

The ochrey olive hue, so common in the clay of the marl region further to the southwest, is seen here upon the road, and though no marl has been dug, I do not doubt its existing in this quarter. Marl, declared to be good, has been found two miles to the northwest of Willow Tavern.

The country between this and Allentown is, for a certain distance, somewhat hilly, then flat and very sandy. Hills occur of some magnitude near the head waters of Rocky brook, and range from east to west. The highest is called Pine Hill, and is the same which is seen so conspicuously from Hendrick Conover's insulated hill, as before noticed. We pass through a gap in this range, in coming from the northeast to the Willow Tavern.

Two ranges of high grounds seem to extend in parallel directions to the southwest, one on each side of the road going to Wrightsville, before reaching which place, however, the western one is crossed. To the east is Cream Ridge.

At the head of Montgomery's mill-pond, near Allentown, Mr. Burden has dug in search of marl. It is very poor (of the spurious kind), no green grains being visible, and it tastes strongly of copperas. At the rate of twenty loads to the acre it destroys the crop. A very slight dressing, however, was thought to be beneficial to potatoes. The stratum is the blue sandy clay usually so astringent.

At Crosswick's, Gideon Middleton has a marl pit near the mill, in which the layers are as follows:

1. A micaceous tough clay on the top.

2. A rather greenish gray marl, somewhat micaceous, but pretty rich. Beneath this, one foot of ferruginous marly concretions, each about the size of a man's head.

3. A dark blue marl.

4. A black sand and marl.

In sinking a well at his house, many years ago, the beds traversed were ten feet of yellow sand, then twenty-seven feet of marl, and below all a white sand. Low down in the pit just spoken of, shells, belemnites, &c. occur. Fossil wood, with much pyrites attached, is sometimes seen in the marl pit near the bottom.

This marl is highly fertilizing, as Mr. Middleton's fields show. Mr. M. has *mixed it with lime with very beneficial results.* In the upper stratum, yellow incrustations of efflorescent sulphate of iron abound.

Marl from the farm of Gideon Middleton.

Composition.—In 100 parts:

Greensand, - - -	68·00
Clay, - - - -	29.00
Quartzose sand, - -	3·00
	100·00

The proportion of *potash* which this marl contains, deduced from that in the greensand, is 7·8 per cent.

The marl is very good one mile lower down upon Crosswick's creek, at David Killey's. It lies in a bank on the side of the meadows along the creek, and has a top layer of the black astringent clayey or spurious marl. There is a good marl on Crosswick's creek, half a mile above Hogsback landing, and I am told it extends still lower down. This proximity to the railroad is a matter of much importance to the adjacent region.

Near the Sand Hills, and in places between these and Bordentown, the lower or spurious marl stratum is visible in the sections of the railroad, and I am now firmly of the opinion, that the clay

with lignite at Bordentown landing and below, is the lower bed of the marl formation, and identical with the astringent blue clay bed beneath the true marl or greensand at the base of Nevesink Hills and elsewhere in Monmouth county, and throughout a great portion of the whole marl region.

Shelltown.—Howard's marl is near this place on the south side of Crosswick's creek, and presents both the true marl stratum and the astringent clay. The marl is dark, friable, smells of sulphur, and is found to be very efficacious. The overlying lead-coloured clay is somewhat micaceous, and contains a trivial quantity of the greensand, being in all respects like the underlying bed which shows itself at Wall's mill near Burlington. It resembles very much the character of the bed where it caps the marl at Crosswick's and in the neighbourhood.

On the road from Shelltown to James S. Lawrence's, which is one mile southwest from Varmington, the same overlying bed is exposed in numerous places in the banks of the meadows.

All these cases are adduced to show that the true marl overlies and alternates with the dark astringent clay along nearly the whole northwestern edge of the marl tract, as, for example, near Burlington and Camden.

Fine exposures of the marl offer themselves to view in the vicinity of the residence of Mr. Lawrence. The soil itself is a brown ferruginous loam, being a portion of a narrow tract of red clayey soil, which extends a considerable distance northeast and southwest, passing by Arneystown, and exibiting wherever it is seen, every evidence, from its texture and the minute water-worn grains of quartz, of its having resulted from the breaking up of an overlying stratum of brown sandstone. In some of Mr. Lawrence's fields, it contains a very sensible quantity of the green granules. The upper part of the marl stratum here differs materially in aspect from the lower. For a thickness of several feet, it is little else than a mass of decomposed shells almost invariably in the state of casts, the shells replaced by oxide of iron. An inconsiderable proportion of the green grains is mingled with a yellowish white pasty matter, which is a mixture principally of sulphate and carbonate of lime, derived no doubt from the shells, and which imparts many valuable qualities to the marl.

The lower stratum is a mass of dark greensand, in which we

witness few traces of the changes noticed in the materials of the mass above. The quantity of oxide of iron in the free state mixed with the marl causes it to be rather hard to dig; this is the case with nearly all the more ferruginous kinds, but a brief exposure to the air renders it friable, when it is found to be a very powerfully fertilizing marl. Striking benefits result from the use of this marl when it is applied in the ratio of about ten loads to the acre. In this bed have been found teeth of the *mosasaurus* and several bones apparently of the fossil crocodile. Mr. Lawrence states that his lower or dark green marl, which is very full of the astringent matter or sulphate of iron, will not admit of being lavishly employed, for it then invariably *poisons the crop*. If as much as twenty-five loads be used, the growth of the corn is seriously checked; nor does it recruit until late in the season, after which the vegetation is wonderfully quickened. The upper stratum, on the other hand, will admit of being applied in any excess, one hundred loads or even more, producing no deleterious effects upon the crop. Where the banks of the meadows are high, a different stratum from either of the previous two is seen, and to all appearance occupying a higher place in the series. This is the calcareous sandy stratum which in another part of this Report I alluded to as being in all probability a deposit of the same date with the limestone of Vincentown and Mannington. It is here a yellow calcareous sand with scattered grains of marl, and with a multitude of solid casts of various fossils, some of which do not show themselves in the green marl beneath. In this bed I have procured *coprolites*.* All the casts in question consist chiefly of carbonate of lime in an earthy state mixed with a little clay and sand.

The stratum in some places is more than twenty feet in thickness. Being the upper bed, it is in many instances the only accessible one, in which case I think it deserves to be employed as a substitute for marl, not merely for the amount of calcareous matter in it, but for the quantity of the greensand. Bones of some reptile, the *crocodile* apparently, are found in this stratum, and we may hence form a conjecture of the source of the coprolites. From the same bed we may procure solid internal casts

* *Coprolites*, are the fossilized dung of extinct animals.

of a *fossil crab*, two species of *baculites*, teeth of the cro-
ınd many interesting species of bivalve and univalve shells.
leep ravine on the opposite or west side of Crosswick's
nd a little lower down than where the previous beds are
ıd very near the line of an ancient Indian path, we have
ɔition of a very different group of beds.
ɯpper layer is a yellow sand. A little beneath this, there
a brownish, ferruginous, sandy rock, characterized by
f the *ostrea falcata*, identical in all its features with the
containing ostrea falcata, and resting high up in the cliffs
Nevesinks. Next beneath is a dark siliceous sand, with
shells, and masses which appear to have been lignite or
ood, replaced by a sandy clay. This bed is very astrin-
e surface in many places being coated with the yellow
:ence. Lower still there exists a mottled gray and yellow
ıd beneath all a gray sand with lumps of what was once
but is now clay, having all the markings and occupying
:e of the woody matter now removed.
ɔhn Miers, two miles south of the localities above de-
, excellent marl is seen in two layers, the top one being a
een, with little or no white incrustation upon the grains,
ı graduating into the inferior, or dark green marl, which
o be rather less friable and considerably more ferruginous.
ains in the lower part of the stratum acquire, when drying
eap, the white tasteless incrustation or efflorescence so
n to the marls of the region, and which chemical experi-
ıtablishes to be the sulphate of lime or gypsum.

From the farm of John Miers, on Lahaway creek, near
rstown, Upper Freehold township, Monmouth county.

Upper part of the bed.

ription.—Colour, light green, clayey and adhesive. The
l granules, which are small, are of the same bright green

position.—In 100 parts:

Greensand, - - -	84·5
Clay, - - - -	14·5
Quartzose sand, - -	1·0
	100·0

The proportion of *potash* which this marl contains, deduced from that of the green grains, is 9·7.

Lower portion of the stratum.

Description.—Colour, bluish-gray, texture clayey and tenacious. The washed granules dark, almost black, and very large.

Composition.—In 100 parts:

Greensand, - - -	77·45
Clay, - - - -	22·55
Quartzose sand, - -	none.
	100·00

The proportion of *potash*, by analysis, is 9 per cent.

It is an observation made in this neighbourhood, and one in complete accordance with my observations throughout the marl tract, in its range from hence through Burlington and Gloucester counties, and even Salem, that when the *light green* shows itself it is usually along the eastern side of the marl belt, and invariably occupying a position on the top of the dark greensand. The latter, I find in many districts to be esteemed the most efficient of the two varieties.

At *Snuff Mill*, on a small tributary of Crosswick's creek, about one mile north of New Egypt, we witness the same limestone bed which appears lower down the State, at Vincentown, and in Salem county. It holds the same position on the top of the green marl, is a stratum of about a foot in thickness, and contains the same corals or zoophytes—for example, the same alcyonia, and the same shells seen in the districts where this stratum of rock is of more important thickness.

At *Fuller Horner's*, on Crosswick's creek, about a third of a mile below New Egypt, there is a bank exposing the strata, where, during the last twenty years, enormous quantities of marl have been procured for the use of the neighbourhood. The section is between twenty and twenty-five feet high. Near the top of the bank, the upper layer is a greenish siliceous and slightly calcareous sand, and beneath this occurs the rubbly, straw-coloured, and somewhat sandy limestone, the frequent capping to the marl. Both these layers are represented in precisely the same order

near Vincentown. In the bank before us the limestone is rarely more than one foot thick, and reposes upon the greensand, or marl bed, which consists of a series of thin layers of different tints, and various degrees of purity, occupying a depth of at least twenty feet.

This is a locality containing some very interesting fossils, but the present is not the place to treat of them. The marl has the very usual odour of sulphur, and exhibits, when dry, the gray or white efflorescence. It enjoys a high reputation as a manure. Most of the shells in it show that the carbonate of lime has been nearly all supplanted by oxide of iron, and here, as in the instance of many other greensand marls, the virtues of the mass are not to be attributed to the lime, but to the specific power of the constituents of the dark granules, chiefly the potash.

Marl from the farm of Fuller Horner, New Egypt. Upper part of the bed.

Description.—Colour dark olive-green; washed granules very dark green, size large.

Composition.—In 100 parts:

Greensand, - - -	100
Clay, - - - -	none.
Quartzose sand, - -	none.
	100

The proportion of *potash* which this marl contains by analysis, is 11 per cent.

Marl from the bridge at Hornerstown, Monmouth county.

Description.—Colour, a rather light green. The washed grains quite small, and of a richer green.

Composition.—In 100 parts:

Greensand, - - -	75·90
Clay, - - - -	20·10
Quartzose, - - -	4·00
	100·00

The proportion of *potash* in this marl by direct analysis, is 9.1 per cent.

Near *Arneystown*, the marl is to be met with in nearly all the meadows and low grounds. The soil is the red or brown loam, derived from the destruction of the brown ferruginous sandstone, one of the principal upper beds of the secondary strata of the region.

The underlying marl does not, to my knowledge, offer either the overlying light-green layer, or the still superior seam of limestone, a fact corroborating what has been said, that these lie chiefly upon the eastern or ocean side of the marl tract. The dark marl here is highly effective upon the crops.

Between Arneystown and Hornerstown, we meet the same superior thick mass of calcareous sand full of organic remains; these are usually in the state of solid casts of the *interior* of the shells. The whole corresponds to what we see nearer to Varmintown, at Mr. Lawrence's. The spot where this bed best shows itself is on the hill side overlooking the meadows at Crosswick's creek, and it is thought that we may behold here, as at Lawrence's a slight dip of the strata to the southeast. Upon the other side of the valley, on a level with the meadows, we meet with a gray loose sandstone full of *ostrea falcata*, in an undissolved and beautifully pearly condition.

At *Cookestown*, a rock, equivalent to the Vincentown seam of limestone, is seen lying near the level of the stream.

At *Imlay's*, where the Monmouth road crosses Crosswick's creek, and about half a mile below Fuller Horner's beds, the marl series is exposed at a considerable elevation above the creek. Gray sand shows itself on the top, then follows a yellow sand, with ferruginous bands of cemented shells, and then sand with green grains, through a thickness of several feet, down to the top of the pure greensand stratum.

A light-green marl, four feet thick, full of casts of shells succeeds; below which lies the dark-green marl, rather coherent or slightly cemented by oxide of iron, and a few shells.

The top of this is many feet above the meadows, and I can well comprehend how, by the descent of the meadows to Lawrence's, space enough may exist for the siliceous beds, cha-

racterized by ostrea falcata, to occupy a yet lower place in the series.

Marl from the farm of William Imlay, between Plattsburg and Arneytown, Burlington county.

Description.—Colour, dark olive-green; washed granules, dark clear green, and of large size.

Composition.—In 100 parts:

Greensand, - - -	91·85
Clay, - - - -	6·65
Quartzose sand, - -	1·50
	100·00

The proportion of *potash* in this marl, deduced from that of the greensand, is 10·5 per cent.

Marl from Crosswicks creek, at its intersection with the Mount Holly and Monmouth road.

Description.—Colour, dark earthy green.

Composition.—In 100 parts:

Greensand, - - -	82·22
Clay, - - - -	13·58
Quartzose sand, - -	4·20
	100·00

The proportion of *potash* in this marl, as deduced from the greensand, is 9·6 per cent.

Plattsburg, or *Sykesville.*—Marl of excellent quality is procured at several places in this neighbourhood, as the following analyses will show.

Marl from Poke Hill, near Plattsburg, Burlington county.

Description.—Colour, a greenish olive-gray; washed granules, a rich dark olive-green, rather above the medium size.

Composition.—In 100 parts:

Greensand, - - -	98.0
Clay, - - - -	2·0
Quartzose sand, - -	none.
	100·0

The proportion of *potash* in this marl, by analysis, is 10·7 per cent.

Marl from the farm of Sarah Willis, half a mile northwest of Plattsburg.

Description.—Colour, a rich green; the washed granules have a still richer tint; they are of medium size.

Composition.—In 100 parts:

Greensand, - - -	69·1
Clay, - - - -	28·9
Quartzose sand, - -	2·0
	100·00

The proportion of *potash* in this marl, deduced from that in the greensand, is 7·9 per cent.

Marl from the farm of John Pancoast, half a mile northwest of Plattsburg, Burlington county.

Description.—Colour, light verdigris-green; the washed granules even lighter in colour; size, small.

Composition.—In 100 parts:

Greensand, - - -	76·50
Clay, - - - -	22·00
Quartzose sand, - -	1·50
	100·00

The proportion of *potash* in this marl, deduced from that in greensand, is 8·7 per cent.

Marl from the farm of Thomas Earl, three quarters of a mile northwest of Plattsburg.

Description.—Colour, earthy pea-green; the washed grains, small in size and of a dark sea-green colour.

Composition.—In 100 parts:

Greensand, - - -	56
Clay, - - - -	36
Quartzose sand, - -	8
	100

The proportion of *potash* in this marl, deduced from that in the greensand, is 6·4 per cent.

Marl from the farm of Caleb Newbold, two miles southwest of Plattsburg, west side of Lowland road.

Description.—Colour, pea-green; the washed grains small in size, and of a sea-green colour.

Composition.—In 100 parts:

Greensand, - - -	84·10
Clay, - - - -	15·90
Quartzose sand, - -	none.
	100·00

The proportion of *potash* in this marl, by direct analysis, is 9·2 per cent.

Marl from the farm of Thomas Black, two miles west of Plattsburg.

Description.—Colour, dark dull green, but little changed by washing; granules large.

Composition.—In 100 parts:

Greensand, - - -	90·50
Clay, - - - -	9.50
Quartzose sand, - -	none.
	100·00

The proportion of *potash* which this marl contains, ascertained by direct analysis, is 10·8.

Arney's Mount is a considerable hill at the Friends' meeting-house, one and a half miles southwest from Juliustown. The sandy soil of the neighbourhood, even that of the road, is mixed with the greensand, so that its colour is sensibly influenced by it. Eastward from the meeting-house, a few hundred yards, there is a small opening on the road, where the ferruginous conglomerate has been quarried. Most of the cemented particles in this rock are grains of coarse siliceous sand, but some of them are

felspar. It is very hard and durable, and shows no departure from the horizontal position.

On the top of Arney's Mount, there lies a pretty thick bed of this sandstone; it is largely quarried, dipping very gently to the east. This mount is distinctly visible from *Mount Holly*, from which there is a rather extensive view. The whole surrounding landscape is extremely flat, the eastern horizon, more especially, being perfectly uniform. Marl occurs, near the surface of the fields, to the southeast; its existence being shown by the water oozing forth along the base of the hill or mount.

Marl from the farm of Thomas Coats, half a mile southwest of Juliustown, Burlington county.

Description.—Colour, a very rich verdigris-green; the washed grains of a darker colour and very small.

Composition.—In 100 parts:

Greensand, - - -	77·25
Clay, - - - -	12·75
Quartzose sand, - -	10·00
	100·00

The proportion of *potash* in this marl, deduced from that in the greensand, is 8·8 per cent.

On the Assiscunk (Barker's branch) a little above Slabtown, marl has recently been opened. It is not good, owing to its containing too much of the ordinary impurities. The opening is on the side of the road. It is said to contain fossils.

Higher up, on the same branch, the marl seems to be considerably better, yet it is too siliceous to be ranked as the best kind.

Burlington.—The nearest place to the river where marl occurs in this vicinity, appears to be at the mill-pond near Wall's mill, one mile south of the town. The pit is not deep, owing to the stratum being wet. It is exposed in a spot where the dam some time since gave way, and its top is very little below the level of the original water course. The top of the stratum is covered by a thin, hard, ferruginous crust. The marl is highly siliceous and

micaceous, yet contains a very sensible proportion of the green particles. No fossils appear in it. It has a strong sulphurous odour, and presents the yellow efflorescence and astringent taste of copperas, and resembles pretty closely that at Johnson's, near Mount's mills.

This material manifestly underlies the true greensand, which here and at Bordentown, and indeed generally throughout the belt of country bordering the Delaware, has been extensively swept away along the northwestern margin of the formation by denuding currents.

At *Costill's mill* the marl is pretty much of the same character, containing perhaps rather more of the black clay and siliceous sand. *Sulphuret of iron* also occurs in it, in little nodular lumps. It smells strongly of sulphur. When applied in light dressings to the land, it has been found useful. It is said to contain shells and shark's teeth.

On the *Rancocus*, near Franklin Park, the good marl lies at the level of the tide, being covered by the yellow ferruginous sand, and has much clay mixed with it. It has been found very beneficial, but is regarded as inferior to that which lies higher up the Rancocus. It contains fossils.

Higher up the Rancocus, the marl extends to Pemberton and Vincentown, and, it would appear, almost to the vicinity of the Pine Cottage.

Marl from Pemberton Mills.—Upper part of the Stratum.

Description.—Colour, yellowish pea-green; the washed grains of a darker green and of small size.

Composition.—In 100 parts:

Greensand, - - -	54·13
Clay, - - - -	20·47
Quartzose sand, - -	25.40
	100·00

The proportion of *potash* in this marl, by direct analysis, is 3·5 per cent.

Lower part of the Stratum.

Description.—Colour, very light greenish-gray ; highly clayey and adhesive.

Composition.—In 100 parts:

Greensand, - - -	38·05
Clay, - - - -	26·95
Quartzose sand, - -	35·00
	100·00

The proportion of *potash* which this marl contains, deduced from that in the greensand, is 4·3 per cent.

On the Haybridge run, a mile and a half north of Pemberton, there is very good green marl which is dug near the road. Over this is a thin layer, containing much of the copperas earth in a state of efflorescence.

At Forsyth's, north of the road between Pemberton and Lisbon, and one and a half miles from the former place, there is very good dark-green marl, lying on the surface of the meadow. It contains numerous fossils. On the edge of the meadow, and near the top of the marl, there were found, some years ago, the principal portions of the head of a *mastodon*, and also a tusk, pieces of the tibia, ribs, &c. It would seem, from the state of the bones, and the unworn condition of the teeth, to have been a young one. The head was exposed to the air, lying only eighteen inches below the surface of the meadow, and was much decayed.

In a ravine, on the edge of the meadow, and lying in the yellow sand which covers the marl, there was found a mass having all the external characteristics of *retinasphaltum*.

Shark's teeth, phosphate of iron, &c. occur in the marl of this vicinity.

Birmingham.—The marl is generally of a superior quality along the north branch of the Rancocus, both above and below Birmingham. On the north side of the stream, it is extensively opened on the farm of Jacob Gaskill, where the greensand may be penetrated to a depth of twenty-five feet without serious inconvenience from the infiltration of water into the pits.

Marl from the farm of Jacob Gaskill, near Birmingham, Burlington county.—Lower part of the bed.

Description.—Colour, dark greenish-gray; washed granules, dark olive-green; rather large.

Composition.—In 100 parts:

Greensand, - - -	92·9
Clay, - - - -	6·1
Quartzose sand, - -	1·0
	100·0

The proportion of *potash* which this marl contains, by analysis, is 10·8 per cent.

Marl from the farm of John Woolston, a fourth of a mile south of Birmingham, Rancocus creek.

Description.—Colour, dull grayish-green; the washed grains of a light green colour, and rather small size.

Composition.—In 100 parts:

Greensand, - - -	82·60
Clay, - - - -	10·40
Quartzose sand, - -	7·00
	100·00

The proportion of *potash*, deduced from that of the greensand, is 9·5 per cent.

Marl from the farm of John Dobbins, a fourth of a mile south of Birmingham, Rancocus creek.

Description.—Colour, dark olive-green; texture, granular, granules of a medium size; when washed of a deep full green.

Composition.—In 100 parts:

Greensand, - - -	92·75
Clay, - - - -	6·25
Quartzose sand - -	1·00
	100·00

The *potash*, by direct analysis, in this marl is 10·02 per cent.

Marl from the farm of Mr. Charles Euen, one-fourth of a mile south of Birmingham, on Rancocus creek.

Description.—Colour, sea-green; the washed grains of rather large size, and of a very rich green colour.

Composition.—In 100 parts:

Greensand, - - -	91·35
Clay, - - - -	8·65
Quartzose sand, - -	none.
	100·00

The proportion of *potash* in this marl, by analysis, is 10 per cent.

Vincentown.—The proportion of greensand in the marls of the vicinity of Vincentown, though such as to confer decidedly active properties, is yet somewhat inferior to that of some preceding localities. In other respects these marls are of ordinary purity.

Marl from the farm of Mr. Job Frick, near Vincentown.

Description.—Colour, dull greenish-gray; washed granules of a dark rich green, and of medium size.

Composition.—In 100 parts:

Greensand, - - -	77·55
Clay, - - - -	20·45
Quartzose sand, - -	2·00
	100·00

The proportion of *potash* in this marl, by analysis, is 8·3 per cent.

Marl from the farm of Mr. Benjamin Peacock, near Vincentown.

Description.—Colour, dark grayish-green; the washed grains of a deeper green and small size.

Composition.—In 100 parts:

Greensand, - - -	76·13
Clay, - - - -	15·45
Quartzose sand, - -	8·42
	100·00

) proportion of *potash*, as deduced from that of the green- is 8·7 per cent.

from the farm of Edward Hilliard, half a mile south of Vincentown.—Lower portion of the stratum.

cription.—Colour, verdigris-green; the washed grains of a · colour, and very small.

ıposition.—In 100 parts:

Greensand, - - -	72·58
Clay, - - - -	19·92
Quartzose sand, - -	7·50
	100·00

) proportion of *potash* in this marl, by analysis, is 7·9 per cent.

rstown.—The marl in the meadow midway between Eayrs- and Newbold's Corner, presents something unusual. The are generally coarse and dark green, while some are very almost white, and seem to be decomposing. These owe whiteness to an incrustation of *carbonate of lime*, their in- being of a very light green.

re submit the analyses of two marls from the vicinity of town, by which it will appear that the greensand formation here in considerable purity.

from the farm of Thomas Edwards, half a mile southwest of Eayrstown.

cription.—Colour, lead-gray; contains a few particles of ıate of lime, adhesive; the washed granules are light grayish- , and of medium size.

ıposition.—In 100 parts:

Greensand, - - -	93.5
Clay, - - - -	6·5
Quartzose sand, - -	none.
	100·0

proportion of *potash* which this marl contains, is 10·1 per

Marl from the farm of Messrs. Thomas and William Edwards, near Eayrstown.

Description.—Colour, dark verdigris green; the washed grains, quite small and of a very rich green.

Composition.—In 100 parts:

Greensand, - - -	81·59
Clay, - - - -	18·41
Quartzose sand, - -	none.
	100·00

The proportion of *potash* in this marl, deduced from that of the greensand, is 9·30 per cent.

Points south of the Rancocus.—On Haines's creek, or the main south branch of the Rancocus, one mile and a half below Haines's place, the banks exhibit the black micaceous and astringent clay, ascertained to rest throughout a considerable area *beneath* the true green marl. In a meadow half a mile to the north of Joseph Haines's the two beds are seen in contact.

At Charles Haines's mill, two miles below Medford, on the creek, a section is seen, exhibiting on the top a greenish siliceous sand; beneath this, a gray sand some feet thick, containing a small proportion of the green granules; and under this, the straw-coloured limestone two feet thick.

These beds hold the same order, and are identical in composition with those above the green marl at New Egypt and elsewhere, towards the eastern side of the "marl tract." One-fourth of a mile from the mill, the beds have been cut through, in digging a well, into the greensand underneath. The limestone was reached between seven and eight feet below the surface. It was in thin irregular beds, separated by incohering sand and calcareous grains, similar to the mixture which composes the rock; its total thickness is about six feet; the organic remains are the same which characterize the limestone at Vincentown. The marl stratum here possesses when dry, a dark, slightly greenish-gray hue, the granules being coated with a very copious efflorescence; it resembles the marl at Inskeep's. In the upper part of the bed there is a layer four feet thick, of decomposed shells, (Gryphea, &c.) mingled with the green grains, in a dark friable

brownish mass; the efficacy of this upon the soil is found to be very great. Capping this upper layer, the diluvium contains a bottom band of very ferruginous cemented sand and gravel, a foot and more in thickness.

The extensive range of meadows in which these exposures of the strata occur, meets the meadows of the Rancocus about two miles above the limit of the tide, at Joseph Haines's. They contain marl along their banks almost to the source of the stream. None of the overlying limestone seems to occur nearer the Delaware than this point, for the marl here is the uppermost stratum.

The limestone belt measured from northwest to southeast, appears, as far as exposed, to be about one mile wide, and there are pretty good reasons for concluding that it expands still more to the southeast. In the marl at J. Haines's, shells, shark's teeth and bones are occasionally found.

The marl is traceable as far to the southeast as Pricket's, upon the edge of the sandy tract, denominated from the prevailing timber, *the Pines*. It is here very similar to the upper and moderately pure variety seen in the stratum at Medford.

Near Medford, which is about two miles from the edge of the pines, pretty good marl abounds in all the ravines or meadows adjacent to the town.

Evesham.—Some of the marl in this vicinity is remarkably pure, as the following analysis will show:

Marl from Evesham, Burlington county.

Description.—Colour, a medium tint of green; granules of rather large size.

Composition.—In 100 parts:

Greensand, - - -	100
Clay, - - - -	none.
Quartzose sand, - -	none.

The proportion of *potash*, by direct analysis, is 11 per cent.

On the north branch of Cooper's creek, and about one and a half miles south by west from Swain's, the marl is very extensively laid bare in the banks bordering the meadows. The marl

pits of Mr. Buck, J. P. Rogers and others, are very extensive. At the former, which are low, the marl is of a pretty light bright green; upon drying, it does not become covered with much efflorescence. The excavations enter the stratum about ten feet; no shells or other fossils are seen. The sand of the overlying diluvium contains some of the green granules, and a layer which has somewhat the aspect of a green clay, derived perhaps from the granular marl below. That this overlying bed is certainly diluvium, is proved by the fact of its occasionally filling *troughs* or undulations in the top of the marl, which seems to have been furrowed at some time by rapid currents sweeping over its surface.

At J. P. Rogers', the colour of the marl is darker, being a deep dull bluish green. These varieties in colour are due more often to small admixtures of differently coloured clays than to an intrinsic difference in the tints of the granules themselves. The marl now before us exhibits a copious white efflorescence on drying. It is certainly a curious fact, but is true, as far as I have yet observed, that the darker marls have more of this than the light ones. The dark and light green varieties in this quarter, seem not to be, as in many places elsewhere, distinct beds. At the depth of about ten feet numerous fossils occur. Besides the ordinary shells, there have been found sharks' teeth, and a portion of the jaw of a crocodile, containing three of the teeth in their sockets. A small mass of a black bituminous substance possessing all the characters which belong to *retinasphaltum*, was procured two feet beneath the top of the marl. It is identical in all respects with the mass found near the top of the marl at Forsyth's.

At Cooperstown, upon Cooper's creek, five miles from Camden, there is a marl much in use throughout the neighbourhood; it lies near the surface, being covered by a yellowish mottled bluish clay, apparently the same with the *brick earth* upon which Philadelphia stands.

It has been penetrated in pits which are dry, to the depth of twenty-four feet. It is a tough unctuous bluish clayey stratum, with only a moderate per-centage of the green granules, and a considerable amount of the astringent matters, (copperas, &c.) It contains numerous shells, some of them of great size, an *oxygra costata* found in it weighing upwards of *nine pounds*.

Marl from the farm of William Skinner, near Cooperstown, Gloucester county.

Description.—Colour, dark dull green; the washed granules more distinctly green; these are of large size.

Composition.—In 100 parts:

Greensand, - - -	85·63
Clay, - - - -	14·37
Quartzose sand, - -	none.
	100·00

The proportion of *potash* in this marl, deduced from that in the greensand, is 9·8 per cent.

Within one mile of the Delaware, to the north of Cooper's creek, a bed is reached having all the characteristics of that at Burlington and near Spotswood. It is highly astringent, though when used in moderation it has been found to be serviceable upon the potato crop. Shells and shark's teeth are said to have been found in it, though of this I have not been able to get distinct information.

LOCALITIES BETWEEN CAMDEN AND SALEM.

Good marl abounds on Big Timber, Woodbury, and Mantua creeks, within the limits already designated. In the vicinity of Barnesborough, the proportion of greensand in the stratum gives it a high degree of fertilizing power. The following analyses will serve to show its composition in this portion of the tract.

Marl from the farm of Thomas Bee, Esq., Union Cross-Roads, about five miles southwest of Woodbury, Deptford township, Gloucester county.

Description.—Colour, rich verdigris green; the washed grains of a deeper green.

Composition.—In 100 parts:

Greensand, - - -	92·48
Clay, - - - -	7·52
Quartzose sand, - -	none.
	100·00

The amount of *potash* in this marl by absolute analysis, is 10·35 per cent.

Marl from the farm of Josiah Heritage, two and a half miles east of Barnesborough, Gloucester county.

Description.—Colour, dark olive-green; washed granules still darker, approaching to black; size, rather large.

Composition.—In 100 parts:

Greensand, - - -	93·70
Clay, - - - -	6·30
Quartzose sand, - -	none.
	100·00

The proportion of *potash* in this marl, by analysis, is 10·4 per cent.

Marl from the farm of Joseph Clarke, three quarters of a mile east of Barnesborough.

Description.—Colour, very dark greenish gray; the washed grains, quite coarse and of a dark sea-green colour.

Composition.—In 100 parts:

Greensand, - - -	84·31
Clay, - - -	14·69
Quartzose sand, - -	1·00
	100·00

The proportion of *potash* in this marl, by direct analysis, is 9 per cent.

Marl from the farm of Mr. Hoffman, one mile and a half from Barnesborough.

Description.—Colour, rich verdigris green, granular; washed grains unchanged.

Composition.—In 100 parts:

Greensand, - - -	85·58
Clay, - - - -	13·42
Quartzose sand, - -	1·00
	100·00

The proportion of *potash* in this marl derived by direct analysis, is 9·5 per cent.

Marl from the farm of John Gaunt, one mile and a quarter west of Barnesborough.

Description.—Colour, dark gray, somewhat tinged with oxide of iron; granules large, and when washed of a dull earthy colour.

Composition.—In 100 parts:

Greensand, - - -	82·45
Clay, - - - -	17·55
Quartzose sand, - -	none.
	100·00

The proportion of *potash* deduced from that of the greensand, is 9·4 per cent.

Marl from the farm of James Jehnes, one mile and a quarter west of Barnesborough.

Description.—Colour, pale yellowish green, somewhat clayey and cohesive in texture; the washed grains are dark green and of medium size.

Composition.—In 100 parts:

Greensand, - - -	90·22
Clay, - - - -	8·78
Quartzose sand, - -	1·00
	100·00

The proportion of *potash* which this marl contains as deduced from that in the greensand, is 10·1 per cent.

At Carpenter's Landing, and about one hundred yards north of Mantua creek, the blue clay, containing a small proportion of the green granules and much siliceous sand, displays itself upon the road where the top of the stratum holds up and discharges the water. It is seen very generally upon the side of the marl tract next the river, and may, in nearly every instance, be known by the water which it throws out, and the astringent impregnations contained in it.

A pretty deep section of the beds belonging to this portion of the marl region, is beheld in Richard's Hill, about two miles north of Mullica Hill. A loose yellowish sand containing a few of the green grains, and having the depth of about five feet, occurs on top, being underlaid by about seven feet thickness of ferruginous sand full of disintegrating shells, casts, and concretions, intermingled with a small amount of the greensand or marl grains. Below this there occurs a brown ferruginous sand, containing a few of the granules, indistinct casts, and cemented lumps or concretions of the same with the calcareous matter of the shells. Beneath all, and nearly at the base of the hill, is a bed of unmixed ochreous ferruginous sand, very yellow. It has been dug by the meadow side, and applied to the soil, but with what good results I know not. By adverting to the section at Mullica Hill, to be given next, it will be seen, that this last bed is in all probability the same which lies at the base of the series there, and that to search, therefore, lower in the earth at this place for a purer marl than that half way up the hill, would be to experiment without hope of success, or at least any that could be justified by our present knowledge of the marl stratum in this quarter.

About four miles northeast of Mullica Hill, a marl is dug in a ravine near the road which leads to Woodbury, which is of a dark green colour, and found to be extremely beneficial upon the land.

Analysis shows it to possess the following

Composition.—In 100 parts:

Silica, - - - -	52·05
Protoxide of iron, - -	23·20
Alumina, - - -	7·50
Potash, - - - -	11·20
Water, - - - -	5·25
Lime, - - - -	a trace.
	99·20

Mullica Hill.—At the village of this name, a fine escarpment, formed by the valley of Raccoon creek, exposes an interesting series of beds through a height of about forty feet. The upper-

most deposit of all, is about six or eight feet of diluvial sand and gravel. In the descending order the beds are:

1. A light-coloured bright *greensand*, very free from any foreign substance, if we except a moderate share of greenish clay. It has all the aspect of the light-green or upper marl of many other localities, the efficacy of which has been proved in some cases to be equal to that of the darker stratum which lies beneath; notwithstanding which, the farmers of the vicinity deem it to be quite inert, and therefore erroneously call it a clay. It is admitted that very imperfect attempts have been made in using this material as a manure, and I cannot but believe that a too precipitate judgment has been passed upon it; for, as the following exhibition of its chemical constitution shows, it differs but little from many marls of long acknowledged efficacy. Its composition, it will be seen, does display a less than ordinary proportion of potash.

Analysis of the light-green Greensand of Mullica Hill.

Composition.—In 100 parts:

Silica, - - - -	52·32
Protoxide of iron, - -	27·56
Alumina, - - -	8·94
Potash, - - - -	5·50
Water, - - - -	5·42
	99·74

2. A chocolate-coloured bed, in which about one half is the green granular matter and one half a fine clay of a light purple or chocolate tint. This also has all the features of a good marl, though it is not reputed to have any power.

3. A thin seam, not more than a foot in thickness, of a dark bluish-green marl, *unquestionably* very good.

4. A bed consisting of dark greensand and shells in the state of casts; the shelly matter being all replaced by oxide of iron.

5. A dark yellow ferruginous sand, with casts of shells and ferruginous concretions, and a small proportion of the green granules.

6. A dark yellow ferruginous sand, almost entirely free from the grains of marl, and containing no trace of organic remains.

In the meadows east of Mullica Hill about half a mile, excellent marl is dug from a level many feet higher than the bed of the stream. As far as the general aspect of the surface enables us to judge, the position of this bed is lower than the green stratum in Mullica Hill; but whether they are different horizontal beds, or one and the same stratum connected by a slight dip to the east, are points demanding additional research to settle.

The width of the visible marl tract in the neighbourhood of Mullica Hill, is about three miles.

The several beds seen at Mullica Hill are discernible in the same relative positions in various places more to the southwest. At Colston's, four and a half miles off, the marl is very good.

The analyses which follow will exhibit the character of the marl in the neighbourhood of Mullica Hill.

Marl from the farm of Isaac Sherman, one mile east of Mullica Hill.

Description.—Colour, dark-green; the washed grains, small and of a deeper tint.

Composition.—In 100 parts:

Greensand, - - -	90·37
Clay, - - - -	7·63
Quartzose sand, - -	2·00
	100·00

The proportion of *potash* in this marl by analysis, is 9·9 per cent.

Marl from the farm of Michael Allen, half a mile north-east of Mullica Hill.

Description.—Colour, light pea-green; the washed grains, medium size and of a darker green colour.

Composition.—In 100 parts:

Greensand, - - -	96·36
Clay, - - - -	3·64
Quartzose sand, - -	none.
	100·00

roportion of *potash* which this marl contains, as obtained sis, is 12 per cent.

l from the estate of William Howe, Mullica Hill.

iption.—Colour, dull verdigris green; the washed grains ier green, and small in size.

osition.—In 100 parts:

Greensand, - - -	91·95
Clay, - - - -	8·05
Quartzose sand, - -	none.
	100·00

roportion of *potash* in this marl by actual analysis, is 10·2

rom the farm of Mr. Jonathan Coulson, one mile from Mullica Hill.

iption.—Colour, dark grayish-green; the washed grains, size, and of a deeper green colour.

osition.—In 100 parts:

Greensand, - - -	86
Clay, - - - -	11
Quartzose sand, - - -	3
	100·00

proportion of *potash* in this marl deduced from that in the nd, is 9·8 per cent.

rom the farm of Josiah Lippincot, one mile south-southwest of Mullica Hill.

iption.—Colour, dull grayish-green, owing to the presence ; the washed granules dark green, and of medium size.

osition.—In 100 parts.

Greensand, - - -	89·52
Clay, - - - -	7·88
Quartzose sand, - -	2·60
	100·00

The proportion of *potash* deduced from that in the greensand, is 10·2 per cent.

Marl from the farm of Elijah Horner, one mile and a half southwest of Mullica Hill, Gloucester county.

Description.—Colour, rich green, of medium tint; washed granules dark, and of large size.

Composition.—In 100 parts:

Greensand, - - -	90·75
Clay, - - - -	8·25
Quartzose sand, - -	1·00
	100·00

The proportion of *potash* shown in this marl by direct analysis, is 10·8 per cent.

Marl from the farm of John Doull, between Woodstown and Mullica Hill, three miles from the former.

Description.—Colour, dull earthy green; the washed grains of a dark green and very small in size.

***Composition.*—In 100 parts:**

Greensand, - - -	89·55
Clay, - - - -	10·45
Quartzose sand, - -	none.
	100·00

The proportion of *potash* in this marl, deduced from that in the greensand, is 10·2 per cent.

Woodstown.—The exposed portion of the marl tract opposite Woodstown is of inconsiderable width, extending from a little east of the village to about one mile and a half northwest of Sharptown. In this neighbourhood, the streams cut rather deeply into the bed, and reveal very nearly the same varieties of the marl or greensand as at Mullica Hill. Upon Old Man's creek, the marl is found as far towards the Delaware as Skulltown, which indicates a wider expansion of the deposit than might be

inferred from confining our observations to the exposure upon Salem creek. The marl of Skulltown resembles closely that which is seen in many other places as we approach the Delaware.

The excavations at Woodstown are very extensive in consequence of the excellent quality of the material and the circumstance that this is near the extreme southwestern termination of the marl tract, or at least of that portion of it which lies at a sufficient elevation to be of easy access. The features of the stratum where it is opened in the eastern bank of Salem creek, are such as belong to a great number of other localities, more particularly within the southern half of the marl region.

The beds in the descending order are as follows:

First, the usual covering of diluvium, in which there abounds a considerable quantity of white quartzose gravel, and near to the top of the subjacent marl a number of large rounded blocks of a yellowish sandstone, scarcely calcareous. It is close grained, and often excessively tough. It has been derived evidently from a stratum once in place upon the upper surface of the marl, a portion, I have no doubt, of the bed which still occupies that position in many places not remote. I see every reason to consider it as representing the stratum known as the siliceous limestone of Mannington, Vincentown, and other points. It seems to differ from this rock in the relative proportion of the sand and lime, containing but very little of the latter. At the bridge over Salem creek about a fourth of a mile to the west of the marl pits where these rounded blocks occur, there exists in an undisturbed condition a stratum of rock in the very position here assumed, and of a composition and aspect strictly intermediate between the almost pure limestone, and the above mentioned almost perfect sandstone. It lies close to the water's edge, and has therefore been little noticed. It effervesces pretty actively with an acid, and has been found when burned in the small way to yield a lime capable of slaking. It possesses a yellowish-gray hue, showing the ordinary flinty sand which is its main ingredient, and in addition, a trivial per centage of the green granules.

The next deposit is the light-green marl, which does not overlie the dark green in all parts of the bed, being absent in all the excavations nearest the town. In the banks lower down the creek, as at Mr. White's, the section exhibits a layer of the light green or

upper marl four or five feet thick, resting upon the dark green, which is here called *blue marl*, and from which it is occasionally separated by a crust of cemented ferruginous matter an inch or two in thickness. Mr. White has applied the material of this upper stratum to a portion of his soil without any apparent benefit to the crops, and his sentiment is, that it is destitute of fertilizing powers. In the pits farther up the creek, where a thin stratum of it occurs, it is dug and use is made of it, though the farmers prefer the marl from the darker bed below.

In the banks nearest the town, we behold only the lower marl penetrated in some places to the depth of fourteen feet, and resting under the gravelly diluvium, from which it is parted by a thin cemented ferruginous crust, a proof of the imperviousness of the stratum, and the facility with which the water penetrates the diluvium, and brings down the oxide of iron which it contains. As the covering of diluvial sand and gravel increases in thickness in receding from the creek, it is becoming a daily augmenting obstacle to the uncovering of the marl, rendered more serious by the copious ingress of water from the marl itself. I take this place to recommend attention to the advantages to be derived from the application of some simple machinery, for the purpose of more effectually elevating the marl and draining the pit, that it may not be necessary to abandon each excavation at the trivial depth of ten or twelve feet, and to incur the labour of uncovering fresh surfaces of the marl bed.

Marl from the farm of Michael Nulls, three miles from Woodstown.

Description.—Colour, dull green; the washed grains, very fine and of a very rich sea-green colour.

Composition.—In 100 parts:

Greensand, - - -	83·5
Clay, - - - -	14·5
Quartzose sand, - -	2·00
	100·00

The proportion of *potash* in this marl deduced from that of greensand, is 9·6 per cent.

Marl from the farm of Mr. Benjamin Coulson, three miles from Woodstown, on the road to Mullica Hill.

Description.—Colour, very rich verdigris green; washed granules, dark rich olive-green, rather large in size.

Composition.—In 100 parts:

Greensand, - - -	90
Clay, - - - -	10
Quartzose sand, - -	none.
	100

The proportion of *potash* in this marl by analysis, is 10·1 per cent.

Marl from the farm of John Dickinson, two miles from Woodstown.

Description.—Colour, light sea-green; the washed grains, differing from the original only in their deeper colour.

Composition.—In 100 parts:

Greensand, - - -	92·59
Clay, - - - -	7·41
Quartzose, - - -	none.
	100·00

The proportion of *potash* in this marl by direct analysis, is 10·4 per cent.

Marl from the farm of Mr. Allen Wallace, two miles from Woodstown.

Description.—Colour, dark sea-green; washed granules, still darker, size rather large.

Composition.—In 100 parts:

Greensand, - - -	90·00
Clay, - - - -	8·00
Quartzose, - - -	2·00
	100·00

The proportion of *potash* which this marl contains by analysis, is 10·2 per cent.

Marl from the farm of Jonathan Cauley, three quarters of a mile from Woodstown.

Description.—Colour, a clear light-green; washed granules, a little darker; size, large.

Composition.—In 100 parts:

Greensand, - - -	86
Clay, - - - -	14
Quartzose sand, - - -	none.
	100

The proportion of *potash* which analysis shows in this marl, is 10·3 per cent.

Marl from the farm of Elizabeth Borton, two miles north-east of Woodstown, Gloucester county.

Description.—Colour, dark grayish green; washed granules, dark-green, of medium size.

Composition.—In 100 parts:

Greensand, - - -	90·13
Clay, - - - -	9·87
Quartzose sand, - -	none.
	100·00

The *potash* in this marl deduced from that in the greensand, is 10·3 per cent.

Marl from the farm of Mr. Jonathan Riley, Woodstown

Description.—Colour, dull greenish gray; the washed gr[illegible] of a very rich sea-green colour and very small in size.

Composition.—In 100 parts:

Greensand, - - -	88·28
Clay, - - - -	11·72
Quartzose sand, - -	none.
Carbonate of lime, -	a trace.
	100·00

The proportion of *potash*, as deduced from the greensand, 10·1 per cent.

Marl from the farm of Mr. Samuel White, Woodstown.

Description.—Colour, light sea-green; the washed grains arse and of a dark sea-green colour.

Composition.—In 100 parts:

Greensand, - - -	88·26
Clay, - - - -	8·74
Quartzose sand, - -	3·00
	100·00

The proportion of *potash* in this marl, by direct analysis, is ·3 per cent.

Marl from the farm of Mr. Henry Guest, near Skulltown.

Description.—Colour, dull sea-green; the washed grains small size and of a dark sea-green colour.

Composition.—In 100 parts:

Greensand, - - -	48·30
Clay, - - - -	21·47
Quartzose sand, - -	30·23
	100·00

The proportion of *potash* in this marl, as deduced from the eensand, is 5·5 per cent.

arl from the farm of Paul Skull, three miles northeast of Skulltown, Salem county.

Description.—Colour, dull grayish-green; the washed grains ther large in size and of a deeper green colour.

Composition.—In 100 parts:

Greensand, - - -	91·5
Clay, - - - -	7·5
Quartzose sand, - -	1·0
	100·0

The proportion of *potash* contained in this marl, shown by alysis, is 9 per cent.

In the vicinity of Sharptown, and in two places near Dr. wing's, upon the road from thence to Salem, the marl stratum pretty fully exposed, and seems to present almost precisely the

same succession of beds as seen at Mullica Hill. The upper stratum invariably consists of little else than the green granules, their colour being a light verditer green, and on drying rarely presents the white crust upon the grains seen in the darker sort. The dark green bed possesses a larger share of dark clay intermingled with the grains, which, according to its hue, imparts different tints to the stratum. The grains themselves are not of a very deep green. In Dr. Swing's neighbourhood, the lower bed alone is used, under the impression, not based upon experience, however, that the other is inert. This lower marl has proved to be highly beneficial, the evidences of which may be seen upon Dr. Swing's farm. Yet this lower bed is apparently identical in all respects with the lower stratum at Mullica Hill, where it is pronounced equally inefficient with the upper. This fact ought to show us how many experiments remain to be made before we can pass a final judgment upon the non-existence of fertilizing properties in any of these marls. The lower bed here contains but few shells. At Woodstown there is one layer containing a prodigious abundance of the *gryphea convexa*, and a less proportion of one or two other species. Sharks' teeth, and the bones of the fossil crocodile are not uncommon. The shells possess but a small amount of lime, much of it having been dissolved away, and its place supplied by oxide of iron, from which they derive their brown ferruginous colour. Their presence is therefore of little or no benefit to the marl.

Marl from the farm of Dr. Swing, near Sharptown.

Description.—Colour, dark earthy-green; the washed grains of the same colour, and large in size.

Composition.—In 100 parts:

Greensand, - - -	91·20
Clay, - - - -	8·80
Quartzose sand, -	none.
	100·00

Potash, by direct examination, 10 per cent.

Four miles to the southwest of Sharptown, the surface of the country suddenly drops twenty-five feet, or more, to a lower level

forming an extensive plain, characterized by a clayey soil, and noted in this section of the State for its greater relative fertility. The same tract borders, in a belt a few miles in width, the Delaware river and bay, to Cape May. Throughout the whole of this area, in consequence of the very small elevation of the surface above the tide, the marl stratum is scarcely once intersected by ravines or streams; though I entertain but little doubt that it spreads itself in the southwest direction to the Delaware. At Joseph Bassett's, about four miles from Salem, the marl may be seen at a small depth beneath the surface. It resembles in all respects that which is generally the lower stratum; containing the same mixture of clay, the same shells, and having the same white efflorescence. The principal fossils are *gryphea convexa, exogyra costata, ostrea falcata,* and several spiral univalves in the state of casts, finely preserved, from which we may justly infer that the stratum is not very wet. Teeth and bones also occur.

Marl from the farm of Joseph Bassett, north side of Branch.

Description.—Colour, dirty-green, unchanged by washing.

Composition.—In 100 parts:

Greensand, - - -	89·81
Clay, - - - -	5·19
Quartzose sand, - -	5·00
	100.00

The proportion of *potash* in this marl, deduced from that in the greensand, is 10·3 per cent.

Marl from the farm of James Smith, Mannington Hill, Salem county.

Description.—Colour, rather green, of average depth of tint; the washed greensand is of a rich dark green.

Composition.—In 100 parts:

Greensand, - - -	88·80
Clay, - - - -	10·20
Quartzose sand, - -	1·00
	100·00

proportion of *potash* which this marl contains, by direct is, is 9·5 per cent.

from the farm of Woodnut Petit, near Mannington Hill, Salem county.

Description.—Colour, light yellowish-green; washed granules lark-green, of medium size.

Composition.—In 100 parts:

Greensand, - - -	77·15
Clay, - - - -	18·35
Quartzose sand, - -	4·50
	100·00

The proportion of *potash* in this marl, deduced from that in the greensand, is 8·8 per cent.

I have thus brought my observations as far to the southwest as any traces of the marl stratum show themselves. The chief object of the numerous details here given is to furnish hints, possibly of some future advantage to the several neighbourhoods specified, and moreover to awaken in each district a spirit of *inquiry* and *experiment*, which, should it ever be aroused to vigorous activity, must sooner or later be productive of the greatest benefits to the whole marl region, and to the State at large.

CHAPTER II.

DISTRICT SOUTHEAST OF THE MARL TRACT.

THE physical features of the extensive sandy plain which reaches from the southeastern margin of the greensand, almost to the seacoast, have already been described. It only remains for me to detail a few points in its geology of a chiefly practical bearing. These are some small tracts of *tertiary calcareous marl*, its numerous deposits of *bog iron ore*, and the extensive stratum of white *glass-maker's sand*, with which its surface is covered.

SECTION I.

Tertiary Calcareous Marls.

These are highly interesting in a twofold point of view: first, in reference to our agriculture, as occurring in the midst of a region of sandy soils where the greensand marl, lime, and other like sources of fertility are remote; and secondly, in reference to the progress of our scientific geology, from being the only *tertiary formations* yet discovered in the State, and at the same time the extreme northeastern limit of the very extensive range of the tertiary deposits of the Atlantic border of the middle and southern States.

The geology of these beds is at present somewhat obscure, though the few fossils found prove that they belong to one of the oldest periods of our tertiary formations. Their range is very circumscribed, the only locality of much importance being near the western corner of Cumberland county. Nevertheless, the deposit demands a brief description from its economical value to the neighbourhood where it occurs, and the clew which it may furnish to corresponding strata in other sections of the seaboard region of the State.

These small insulated patches of tertiary, are evidently referable by their fossils to the *miocene* epoch, notwithstanding the disproportion of extinct over recent species. We can at present enumerate only about thirteen clearly recognized species; twelve of which are no longer in existence. Though this proportion might rather imply an *eocene* date for the deposit, the number of discovered fossils is too few to justify us in concluding this to be the actual relation of the extinct to the recent shells; while on the other hand, all the species are either identical with those of the *miocene* of Maryland and Virginia, or exhibit a close analogy of form.

The position of the principal known tracts of tertiary in the State, will be seen by consulting the geological map.

The principal deposit of these tertiary marls occurs in Cumberland county, upon the upper part of Stow creek and its tributaries, but whether it extends farther through the country, con-

cealed by the superficial sands, or, what is rather more likely, occupies what was originally a *cove* or *bay* in the midst of the adjacent *secondary* strata, are points still obscure. At Elwell's pits, about two miles northwest of Roadstown, the deposit shows the following features:

The superficial stratum of the neighbourhood is a rather coarse yellow sand, five or six feet thick in the bank where the marl is excavated. Beneath this, there is a layer four or five feet thick, of a reddish-yellow clay, abounding in traces more or less obscure of fossil shells in an extremely rotten and decayed condition. Beneath this there is a bluish-green clay containing a multitude of the same fossils in a somewhat less decomposed state, though very soft and tender. These two fossiliferous beds are in some places twelve feet thick, and rest upon a dark greenish-blue adhesive sand, bearing a close resemblance to the tenacious sandy clay of the greensand formation. In the adjacent bank it has the prevailing colour of that bed, and the same *astringent* substances (copperas, &c.) which characterize it so generally. The mass of loose friable clay, both yellow and green, exhibits a very considerable proportion of *carbonate of lime* derived from the decomposition of the shells, and the calcareous matter of these fossils themselves. It is a marl calculated to be especially beneficial upon the very sandy land of the vicinity. It will be found valuable as a fertilizer in proportion to the lime which it contains, the crumbly state of the shells, and its freedom from sand.

The description here given of Elwell's marl, will apply pretty well to the other marls excavated upon the same streams, with this reservation however, that the shells in some localities are less rotten and in their nature less destructible, which is the case with those of the oyster. These occur in one part of the deposit at Davis's bank; and also in the greater number of the openings higher up the stream, where the clay seems to possess a rather larger share of sand.

Another stratum of the same geological age, occurs about a mile and a half southeast of Fairton, and near the Rattlesnake run. It is a very thin bed of a similar bluish clay, containing a small proportion of decomposed shells, and resting, like the Stow

creek marl, upon the same astringent argillaceous sand. It also is of two varieties, one containing only oyster shells and much sand: the other being more clayey, and possessing a larger amount of calcareous matter, and the fossils in a very decayed state. The deposit here has not been much developed, though it obviously deserves to be zealously explored.

Much of the value of a marl of this description depends upon the condition of the shells which furnish the lime. These may be very indestructible, the case most generally with the oyster; or on the contrary so easily decomposed, as to be found generally in that chalky and decayed state necessary to constitute a good marl. The largest, and at the same time one of the most abundant fossils in the Stow creek marl, is the *Perna maxillata*, a thick, flat, pearly shell, dividing into numerous thin scales, and valuable from the readiness with which it decays and distributes its calcareous particles.

In excavating marl in this neighbourhood, it is all important to avoid mixing with the calcareous stratum any of the *astringent* matter which lies immediately beneath. This is noxious to the crop and seriously detrimental to the soil. It will be known by its *taste*, and its rarely containing fossils.

I have accompanied this account with the following analyses of these marls, for the purpose of ascertaining for the inhabitants of the quarter interested, the relative efficacy of different specimens from several localities.

1. A specimen of average richness from the marl pits of Mr. Elwell, yielded

Lime, - - - -	25·5	Carbonate of lime 45·5 per cent.
Carbonic acid, - -	20·0	
Greenish residue, chiefly clay, with some oxide of iron,	54·0	
Loss, - - - -	00·5	
	100·0	

The shells in a very rotten chalky state, principally *Pernas*, and a good many small turrited univalves.

2. A specimen of the better variety in Mr. Davis's pits, afforded

Lime,	20·6	Carbonate of lime 36·8
Carbonic acid,	16·2	per cent.
Greenish residue, clay and sand containing some oxide of iron,	63·0	
Loss,	00·2	
	100·0	

The shelly matter much decayed, consisting chiefly of *Pernas* and *Turritella*.

3. The Fairton marl affords from the best variety

Lime,	19·0	Carbonate of lime 34
Carbonic acid,	15·0	per cent.
Greenish residue of clay and sand,	65·5	
Loss,	00·5	
	100·0	

The shelly matter fragments of *Perna*.

The inferior variety, consisting of sand with a little clay and shells belonging to a species of oyster in an undecayed condition, contained, in two examinations made, not more than *four per cent.* of carbonate of lime, after the shells were picked out.

Bog Iron Ores.—This district is characterized by an abundant supply of bog iron ore, which sustains in fact a principal part of its manufacturing industry.

The origin of the deposits of bog ore of the region before us, we can readily understand, by adverting to the very ferruginous nature of nearly all the strata, both the greensand and the beds overlying it. The water, not only in the marl region proper, but throughout the adjacent tracts, contains very generally a considerable quantity of the oxide of iron, which it procures in its passage through the upper strata. Upon coming into the open air it parts with the carbonic acid, the agent by which it is enabled to retain the oxide of iron in the dissolved state; this it quickly precipitates, and hence the accumulations of bog ore in all situations where the low grounds are entered by springs

passing out of the more ferruginous beds of sand and clay. As some of these, the marl stratum for instance, contain a notable proportion of the phosphate of iron, we discover whence the bog ore is contaminated with phosphoric acid, producing a cold short iron. The source of the ore accounts for the interesting fact that, after being dug, the deposit is again renewed after a series of years. In some places, the requisite period does not exceed twenty years. It is essential to the continual deposition of the ore, that the soil in which it is precipitated should not be drained, but that it should be incessantly washed by the ferruginous springs. Where the water from these is enabled readily to escape, and the surface of the ore laid bare and exposed to the rains, the oxide of iron vanishes almost as rapidly as it before accumulated. The lumps retain, it is true, the cellular structure of bog ore, but the matter left consists almost entirely of the more earthy portions, from the solvent power of rain water for oxide of iron in the loosely cohering state in which it exists in the ore. The rain water seems to owe its capacity of dissolving the iron in the ore to the small quantity of carbonic acid which it collects in its passage through the atmosphere.

We derive one important hint from these facts: namely, that those who make use of this variety of ore, should avoid keeping large accumulations exposed to the weather as we so frequently witness at the furnaces in the section of the State where the bog ore abounds. It should be dug, in fact, only as it is needed.

The map accompanying this report, will exhibit the general limits of the several tracts of bog ore, both those confined to the greensand region, and those of far greater extent which occur in the wide sandy country lying between it and the ocean. While the areas represented on the map embrace all the deposits of magnitude and importance, they are not to be regarded as containing the bog ore throughout every portion of their surface. On the contrary, the mineral lies principally along the borders of the main streams and their tributaries, and in the beds of those extensive swamps and wet meadows, with which, owing to the sluggishness of their waters, they are generally surrounded.

Two great deposits, incomparably the largest in the State, border the principal tributaries of the Little Egg Harbour river. The most western of these is connected with the waters of

Atsion river and most of its branches, extending from near the sources of these streams in a tolerably wide belt southeastward to Landing creek. The length of the tract within which the bog ore is found on nearly all the tributaries, is about twenty miles, while we may state its average breadth at three miles. The other, or eastern tract, lies along the Tulpehaukin or Wading river, and its several branches. It covers an area quite as extensive as the former, but the deposit of ore in this latter district is greatly inferior in abundance to that on the Atsion river, particularly in the neighbourhood of Atsion iron works.

The several minor deposits of bog ore are confined to the limits of the marl region.

One of these occurs on Talman's creek, a small tributary to the Rancocus; another is found upon the south branch of the Rancocus near its junction with the north branch; and another lies on the Manasquan river, near the little village called Georgia, in Monmouth county. Other similar deposits are met with on the Manalapan and Machaponix creeks, in Monmouth county, two small tributaries of the South river, which flows into the Raritan.

The usual features of the beds of bog ore, their probable origin, and the peculiarities in the structure of the ore itself, will be understood by the following description of those which occur in the vicinity of Atsion iron works, which may be regarded as representing those deposits generally.

The Atsion river takes its origin within a mile of Long-acoming. In the greater part of its course, it flows through extensive flats or cedar swamps, the water becoming in its passage through these, highly tinged with vegetable matter.

Near to the source of this stream, and at numerous other places along its course, the sand, though of a snowy whiteness on the surface, presents a ferruginous tinge wherever the inferior layers are to be seen. The water oozing from these sands, carries with it more or less of the oxide of iron, derived evidently from the upper and more exposed parts of the stratum, depositing it as it reaches the air.

Within two miles of the source of the Atsion, bog ore is found, though not in very considerable quantity.

The ores which are used at the Atsion works, are obtained from above the furnace, the present excavations are chiefly at

about three or four miles above the pond or dam which supplies the water power. Great quantities of the ore are also taken from the bed of the pond during the winter, when the furnace is out of blast and the water is drained off. The ores which are used at this furnace are, the *loam ore*, the *seed ore*, and the *massive ore*. The swamps of the river (which is rather sluggish) are extensive, and form numerous shallow coves, some of which are covered with water to the depth of about a foot, while others contain a very spongy peat, which is always found on the edges. The ore is chiefly taken from these coves when the water is not too deep, especially along their wet margins. Excavations eight or ten feet square are made, between each of these a thin dike is left, so as to prevent the water from one flowing in upon the workmen in the others. The three kinds of ores are generally found in each hole; the loam ore nearest the surface, the seed ore under this, and the massive ore at the bottom. In some positions, however, only one of these kinds occurs, unaccompanied by the others. In other positions, the several varieties may be seen in their various stages of maturity. The loam ore is that which appears to form first, being in reality merely the infiltration of ferruginous sediment into the soil of the bog. This, which is at first quite soft, becomes by the accumulation of oxide of iron, heavier and more compact. In the centre of many lumps, the mass has a crystalline or regular ore-like character. This structure would pervade the whole deposit, could it be exposed for a sufficient length of time to the correcting action. The loam is thus in time completely replaced by the oxide of iron, which is seldom solid, but of a honeycomb structure, the cavities being more or less filled with yellow aluminous matter. These ores are obtained in various conditions of compactness. That which is partly concreted, partly pulverulent or loamy, is called *young ore*, a variety which experience shows to be better adapted for easy fusion, than the more concretionary harder kinds.

Great quantities of woody matter, such as stumps and trunks of trees, abound in these ore beds, completely converted into oxide of iron. The curious process of replacement which has taken place, has preserved the precise form and structure of the bark and woody fibre, down to the most delicate lines and markings.

Analyses.—The following analyses will display the compositic of the bog ore, in its ordinary varieties.

Bog Ore.—Atsion Iron Works.

Description.—Variety called seed ore.
Composition.—In 100 parts:

Peroxide of iron, - -	66·10
Alumina, - - -	·66
Insoluble matter, - -	20·53
Water, - - -	12·54
	99·83

The *metallic iron* in this ore amounts to 45·83 per cent.

Bog Ore.—Atsion.

Description.—Concreted, cellular; taken freshly from the bog
Composition.—In 100 parts:

Peroxide of iron, - -	68·90
Alumina, - - -	2·37
Insoluble matter, - -	13·99
Water, - - -	14·04
	99·30

The *metallic iron* amounts to 47·71 per cent.

Bog Ore.—Upper Squankum.

Description.—Concreted, cellular.
Composition.—In 100 parts:

Peroxide of iron, - -	76·35
Alumina, - - -	0·23
Insoluble matter, - -	9·29
Water, - - -	12·76
	98·63

The amount of *metallic iron* is 52·94 per cent.

Bog Ore.—Shrewsbury river, near Eatontown.

Description.—Concreted, cellular.

Composition.—In 100 parts:

Peroxide of iron, - -	67·78
Alumina, - - -	a trace.
Insoluble matter, - -	18·54
Water, - - -	8·69
Organic matter and loss,	4·99
	100·00

The amount of *metallic iron* in this ore is 46·98 per cent.

White Sand for Glass Making.

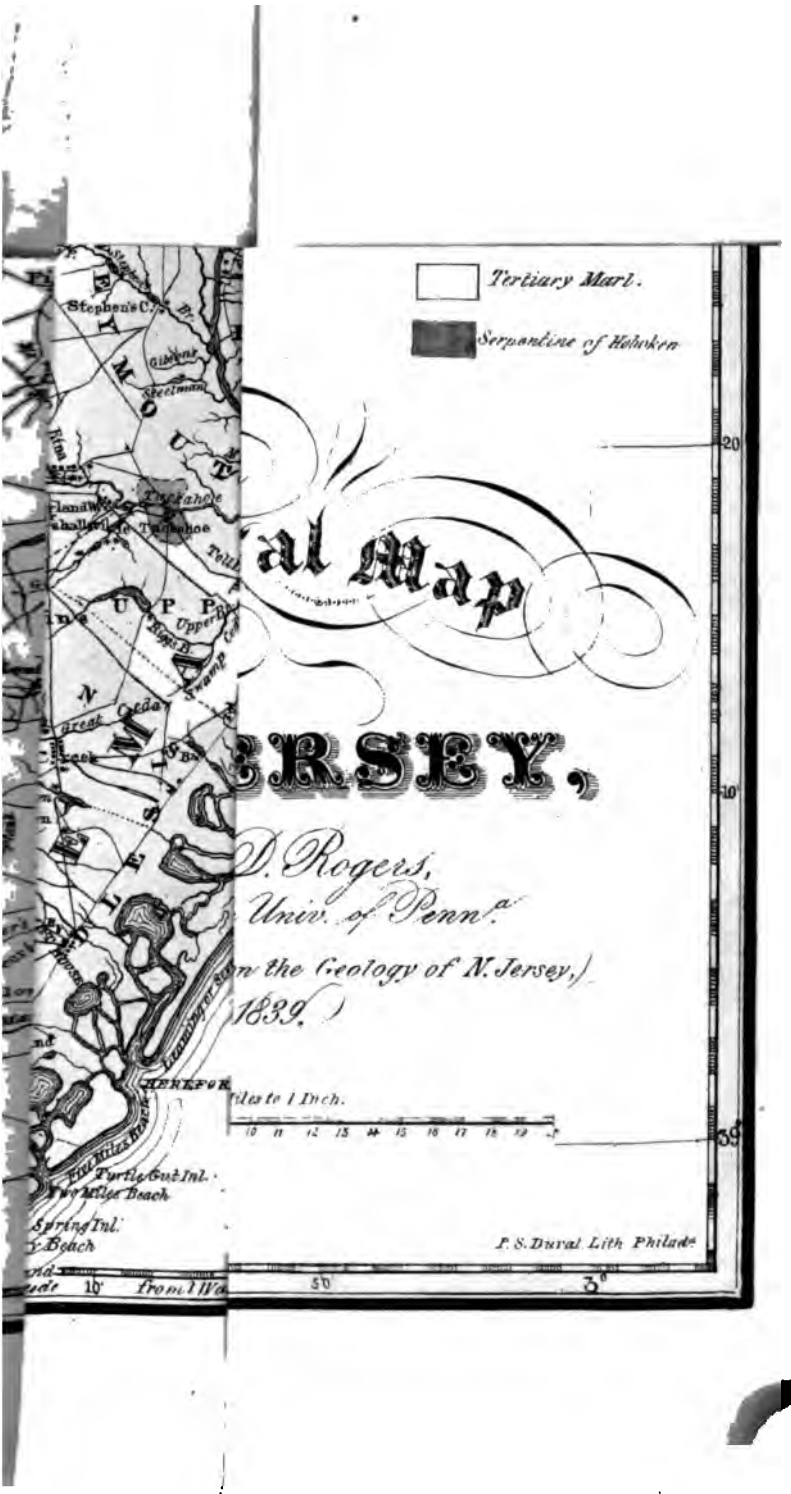
Upon the Maurice river, about three miles below Millville, in Cumberland county, an important locality occurs, which furnishes this valuable material in great abundance. This deposit of sand presents a number of layers, more or less approximating to absolute purity; but previous to its being employed in the glass-house, it is always necessary to submit it to a careful washing, in order to discharge a small quantity of yellowish and slightly ferruginous clay, with which it is intermingled in the bank. After the washing it is a pure transparent quartzose sand, the grains of which are small and of very uniform size. There are five glass-houses in the vicinity of Millville, besides many at a distance, which are supplied with sand from this spot. Numerous other places throughout the very sandy district before us, yield a material equally good, but scarcely any other point yet explored offers the same readiness of access.

In the neighbourhood of Mount Hope much good sand is found; it is used at the Windslow and several other glass works. The sand used at the Waterford glass works is procured in the vicinity of that establishment.

Within two miles of the Brooklin glass works good sand is procured, and is employed both in these and in the Squankum works.

The neighbourhood of Jackson's glass works furnishes a sand well adapted for the manufacture of both window and bottle glass.

FINIS.


Tertiary Marl.
Serpentine of Hoboken
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Stephen's C.
Gibbons
Sheelman
Tuckahoe
Great Cedar
Great Creek
Turtle Gut Inl.
Spring Inl.
P. S. Duval Lith Philada

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FIRST ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY

OF THE

STATE OF NEW JERSEY,

FOR THE YEAR 1854.

By W. Kitchell

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VIEW FROM DELAWARE GAP LOOKING UP THE DELAWARE RIVER

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SUPERINTENDENT'S REPORT.

To his Excellency, Rodman M. Price, Governor of the State of New Jersey:

SIR:—Having been honored by you with the charge of superintending the geological survey of this State, I beg leave herewith to submit the following reports, for the consideration of the Legislature, of the progress of the survey for the past year.

These reports embrace, generally, an account of the plan which has been adopted in prosecuting the work, and some of the results which have an important economical application to agriculture, mining, &c., it being deemed advisable, at this early period, to abstain from any details or theoretical considerations, leaving them to their more appropriate place in the final minute and systematic report.

GENERAL REMARKS.

The object of the survey is to lay before the people of this State as much practical and available information as possible, respecting its natural resources and advantages.

The investigations necessary to the accomplishment of this object, are embraced under the following heads:

1. To determine the different varieties of rocks, and their relative position.

2. Their thickness and geographical range.
3. Their mineral and palæontological contents.
4. Their lithological and chemical character.
5. Their application to agriculture, mining, architecture, &c.
6. Their topographical features.

The discovery of valuable mineral substances; the establishment of principles which will serve as unerring guides to their discovery and extent; and the utter uselessness of searching for them, except in particular geological formations; the derivation, composition and character of soils; their means of improvement and adaptation to particular plants; the plotting and construction of public works, such as railroads, canals, &c.; architecture; great internal improvements; determining the availability of water courses; establishing the most economical plans for drainage—thus rendering unhealthy districts, healthy and unproductive lands fertile; mining; and almost every branch of the arts and manufactures are included in the above investigations.

In order to arrive at the most reliable and thorough results, demanded by such investigations, researches in the following departments of practical science are required:

Topographical Engineering.
Geology.
Palæontology.
Chemistry and Mineralogy.

TOPOGRAPHICAL ENGINEERING.

Topographical and Geographical Maps—Sections.

The topographical or physical features of a country depend on its geological formations. Wherever there is a change in the underlying rocks, there is a corresponding change on the surface, indicating the extent and limits of each formation, and serving as guides to the explorer. The varied aspect of a country, its mountain scenery, hills and dales, plains, water-

falls and courses, all depend, to a greater or less extent, on the change from one formation of rock to another. In making a geological examination of a country, one of the first objects to be accomplished is to represent, on a topographical map, the precise locations and boundaries of the different formations of rocks; also to draw vertical and horizontal sections and profiles of the surface configurations, which will show the order of superposition of the strata and layers of rocks, and their thickness. Hence the importance, in all minute and detailed geological investigations, of an accurate representation of the topographical features of a country. Without this it is totally impossible to describe its orographical structure.

It is to be regretted that, of the many geological surveys of the different States of the Union, none have been preceded by an accurate topographical map. England, France, and some countries of the Continent, understanding its importance, have conducted their geological surveys on a proper basis, and thus furnished to the world that minuteness and accuracy of geological representation and description nowhere to be found in this country.

GEOLOGY.

The term rock, in geological language, not only applies to the hard, solid portion of the earth's crust, but also to the soft and loose materials, such as beds of sand, clay, peat, marl, and soil. They do not occur in a confused and irregular manner, but have a systematic order of arrangement, by which they may be classified into groups depending on their origin, relative age, and general characters.

The most general classification is that which refers to their origin, and which divides them into three principal classes—igneous, aqueous, and metamorphic.

IGNEOUS ROCKS.—The igneous rocks are those which have been formed by the action of heat in the central portion of the earth, and ejected to the surface in a molten state. On cooling, they assume a crystalline aspect, and are generally com-

posed of one or more of the following simple minerals:—feldspar, quartz, hornblende, and mica. They occur in veins, dikes, great irregular masses traversed by joints and divisional planes, constituting mountains, ridges, &c.

Aqueous Rocks.—The aqueous rocks are those which have been formed by the agency of water, from the disintegrated particles of other rocks transported by currents, and deposited as sediment, in the form of strata, beds, layers, laminæ, &c. They very often contain organic remains of plants and animals.

Metamorphic Rocks.—The metamorphic rocks are those which have been formed by aqueous agencies, and subsequently so much altered in their texture by the action of heat, as to resemble igneous rocks. They contain no visible organic remains.

The above is a very general classification of rocks, derived from their origin. They are subdivided into groups called systems, according to their relative age. It is to be regretted that much confusion prevails in regard to their nomenclature.

Every country, and almost every geologist, has a particular system of names, derived either from characteristic fossils, localities, or some lithological peculiarity of the rocks. Those most generally used and understood in this country, are the nomenclature of the English geologists, and that proposed by the geologists of the New York survey. The former is chiefly derived from localities in Great Britain, the latter from localities in NewYork where particular groups of rocks are well developed. As this was the first attempt at a complete classification of the rocks of this country, it has been generally adopted in different States of the Union, and undoubtedly will remain as a standard of comparison. Geological investigation arranges and classifies the rocks, represents their extent, thickness, and order of arrangement, by means of sections, profiles, &c.; points out and describes the valuable mineral deposits of each formation, and the manner in which they may be worked and applied to various economical purposes. But in order to

accomplish this most successfully, it must call to its aid palæontology, mineralogy, and chemistry.

It is by means of the minerals, and organic remains, that the geologist is enabled to determine the varieties of rocks, and their relative ages—one of the most important considerations in a practical or economical view, for it is only in particular formations, and of a particular relative age, that valuable mineral deposits occur. For example, in connection with the igneous and metamorphic rocks (azoic), as granite, trap, gneiss, chloritic, talcose, and hornblende slates, beds of quartz and saccharoidal marbles, or white crystalline limestone, occur the principal metalliferous deposits, as gold, silver, copper, iron, zinc, &c. It is in connection with the aqueous rocks of a certain relative age, that occur the great coal deposits, &c. The former are determined by their lithological character, the latter by their organic remains.

PALÆONTOLOGY.

(ORGANIC REMAINS OF ANIMALS AND PLANTS.)

Its Importance and Relation to Geology.

Palæontology is the science which treats of fossil remains. It has been satisfactorily proved by geological and palæontological research, that at different periods of time the crust of the earth has undergone numerous and various changes; that at one time it was inhabited by no living being; that the waters of the ocean covered its surface; that at a certain period animals and plants sprang into existence, and after living through a few generations died, leaving their remains entombed in the sedimentary deposits of the ocean's bed. Starting from this point, as we ascend in the scale of animal and vegetable existence, we find new tribes of animals and plants successively appearing and disappearing, generation ssucceeding generations, until finally man and his associates, the most perfect of them all, crown the era of animal existence. Some tribes and species have lived through long and successive peri-

ods of thousands of years, others for comparatively but a short period. It is often asked during what length of time have all of these successive changes taken place. But the geologist can compute time only by comparison. That it must have been inconceivably great, no one who studies the vast sedimentary deposits in which these remains are found before man appears upon the surface, and then compares the time which was necessarily required in forming these deposits with the time during which that portion of the earth's crust was deposited in which the remains and works of man are found, will fail to conclude that it is impossible to form an adequate idea of its long duration.

Having perfected and regulated the order of succession in which these changes have taken place, the geologist, commencing with the oldest aqueous rocks, reads the condition of the earth at that period, the state of the atmosphere and its temperature, the changes which took place by aqueous and volcanic agencies, and then, coming as it were to a chapter of more modern history, he reads of another period; and thus, turning page after page, examines successively the changes which have marked the earth's history during a lapse of millions of years.

So regularly have these changes occurred over the whole surface of the earth, that the nature of the organic remains is sufficient to determine the general character of the rocks, and the period at which they were formed.

Perhaps it may not be out of place here to remark, for the information of many with whom I have conversed in different parts of the State during the past year, and who entertained an idea that the principal object in collecting fossils, or organic remains, was merely the formation of cabinets of curiosities at the State capitol, and at the various county seats, at a large expenditure of the public money, that the organic remains found in the rocks constitute the basis of economical geology. It is to them that many of the valuable discoveries in the aqueous rocks are due. The researches of Messrs. Conrad and Hall, have been the means of placing the geology of this country on

its proper basis. Had it not been for the fossils, or remains of plants and animals that were found in the aqueous rocks of the State of New York, the geologists of the survey of that State would not have been able to determine the non-existence of coal in that region, which has been the means of preventing a useless expenditure of thousands of dollars, in searching for that material. It was by means of organic remains that the extent and boundaries of the salt-bearing rocks of that State have been ascertained and accurately defined. It is by means of the occurrence of particular fossils in the marl formations of this State, that the researches of the past year have proved the existence of three distinct beds, and determined accurately the extent and thickness of each of them—a matter of great importance to the land-holders of that section of the State. It is evident, then, that to attempt to describe the geological features of a country, and particularly their economical importance, without considering their organic remains, would be throwing aside the grand principles upon which the science is founded.

CHEMISTRY AND MINERALOGY.

In the preceding paragraphs we have referred to the different formations of rocks which compose the crust of the earth, and the various changes which from time to time they have undergone, as well as the great lapse of years during which these changes have taken place. It is one of the first principles of Natural Philosophy that no change can take place in nature, which cannot be referred to some cause, some active force, as the agency. This fact is satisfactorily demonstrated on every hand in the world around us. Whether we consider those mighty and wonderful changes in the earth, or the more insignificant changes which take place in the merest atom upon its surface, every where the same law holds good.

At this stage, then, of geological investigation, after having examined the varied results of a series of changes that have been going on for myriads of years, it becomes us to ex-

mine into the causes of these changes, and chemistry reveals to us the laws by which they are governed. It has been said by Bischof,* the celebrated chemical geologist, that our earth, as far as we know it, is a great chemical laboratory, in which since the period of its creation uninterrupted chemical processes have been in operation, and will continue as long as it describes its course around the sun. The soil, the atmosphere, animals, and plants, are constantly undergoing changes; and each performs its part in the great and uninterrupted circle of transmutations.

Rocks are composed of one or more distinct substances called simple minerals, such as quartz (silica), feldspar, mica, hornblende, carbonate of lime, talc, oxide of iron, &c. These simple minerals are composed of elementary substances, such as oxygen, hydrogen, carbon, silicium, aluminum, potassium, sodium, calcium, &c., which uniting together in twos form binary compounds; and it is in this latter state that they occur in minerals.

The most common binary compounds are silica, composed of oxygen and silicium; alumina, of oxygen and aluminum; lime, of oxygen and calcium; potash, of oxygen and potassium, &c.

Rocks are sometimes classified according to the predominance of some one of the above binary compounds—as a silicious or arenaceous rock, one in which quartz predominates; an argillaceous rock, one in which alumina or clay predominates; a calcareous rock, one of which lime is the principal constituent; and a carbonaceous rock, one in which carbon prevails.

Almost all the changes that take place in the rocks and materials, organic or inorganic, which constitute the crust of the earth, or grow upon its surface, have their origin in the transformations of the simple elementary bodies. Having a knowledge of the laws by which these transformations are governed, we are able to apply them to the various useful purposes of life.

* Bischof's Geologie—(Introduction.)

It is in consequence of such transformations that soils are formed of the *debris* of rocks, from which plants receive their sustenance; consequently the chemical character of soils partakes more or less of that of the rocks from which they are derived. There are other causes too, which tend to modify the composition of soils in particular localities, as the occurrence of drift, disintegration of bowlders, presence of organic matter, &c. When all of these circumstances are taken into consideration, the general properties of soils are known without subjecting them to minute chemical examinations. The decomposition and disintegration of rocks by chemical agencies is a subject of great importance in rural economy, and one which should receive careful investigation. It has an important practical application in a variety of ways. It teaches the distinctive properties of the soil, to what kind of vegetation it is adapted, and how it may be improved either by cultivation, or by the addition of foreign substances as fertilizers. It is by investigating the laws of nature in her varied chemical and mechanical changes, that we are enabled to imitate them in the practical pursuits of life, and make them subservient to our happiness and prosperity.

RESULTS OF SCIENTIFIC INVESTIGATION IN THE STATE AT THE COMMENCEMENT OF THE SURVEY.

Upon receiving my commission as superintendent of the survey, I proceeded immediately to ascertain what reliable information respecting the topography and geology of the State previous researches had already laid before the people. My principal object was to ascertain if there existed any correct maps, or reliable surveys, which might serve as a proper basis for delineating accurately the geological features of the State. The different editions of the State map, the county maps, and several local surveys were examined. None of them were found to be sufficiently correct, or to furnish the necessary data from which such a map could be compiled as

the objects of the survey, in compliance with the law, demand. Some of the results of my researches were as follows:

The first complete map of the State was compiled by Thomas Gordon, from various local surveys, together with some original surveys procured by an act of the Legislature, passed November twenty-eighth, eighteen hundred and twenty-two, authorising a loan to Thomas Gordon of one thousand dollars, to enable him to obtain additional surveys for the purpose of making a State map. This map, known as Gordon's map, was completed and published in the year eighteen hundred and twenty-eight. During the same year, upon the sixth of March, a resolution was passed by the Legislature, authorizing the Governor to subscribe for one hundred and twenty-five copies. On the fourteenth of February, eighteen hundred and thirty-one, the Legislature passed an act authorizing the treasurer to cancel Gordon's bond, and the Governor to take one hundred and twenty-five additional copies at one thousand dollars.

A second edition of the State map was revised, corrected, and improved, by Robert E. Horner, by a resolution of the Legislature, appropriating one thousand dollars, passed February twenty-fifth, eighteen hundred and forty-seven. This is the last and most reliable edition of the State map. Every other map, made since the publication of this edition, has been compiled therefrom; and the manner in which this was made was sufficient to satisfy me of its want of accuracy, and of its insufficiency as a basis for the geological purposes of the survey. Subsequent examinations and field researches have verified my suppositions, as will be seen by referring to the annexed report of Mr. Viele, the State Topographical engineer.

In the year eighteen hundred and thirty-five, the Legislature passed an act authorizing a geological and mineralogical survey of the State, with an appropriation of one thousand dollars. This survey was conducted under the superintendence of Professor Henry D. Rogers, and the first report of it was made during the following year. March tenth, of the same

year, a further appropriation of two thousand dollars was made. March seventeenth, eighteen hundred and thirty-seven, two thousand dollars more were appropriated; and on the twenty-seventh of February, eighteen hundred and thirty-eight, two thousand copies of a final report were ordered to be published at eighty-seven cents each. This report, containing three hundred and one pages, together with a geological map, was published in eighteen hundred and forty, and embraces a general outline of the geological formations of the State, with analyses of some of the rocks, greensand, and fresh water marls and calcareous tufas, also some general observations on their application to agriculture and the arts.

The survey of Professor Rogers was as minute and detailed as the circumstances and the early day of geological science would allow; and when we take into consideration the meagre means placed at his disposal, and the short space of time allotted for the accomplishment of the work, we can do no less than say, that the outlines of the different formations were accurately defined, and a vast amount of useful information respecting the natural resources of the State presented, resulting in great public benefit, and had the people more generally availed themselves of it, would have been of still greater benefit to them in their agricultural, architectural, and many other pursuits of life.

Previous to the survey of Professor Rogers, local examinations to some extent had been made chiefly in the mineral regions of the northern part of the State, and in the marls of the southern section. Among those who took the most active part in the researches at that time, were Dr. Samuel Fowler, of Franklin, Sussex County, who published several articles in Silliman's Journal, on the mineralogy and geology of Sussex County; Prof. Nutall, Messrs. Vanuxem, Keating, and others, who, from time to time, contributed papers to Silliman's Journal, and the Journal of the Academy of Natural Sciences, of Philadelphia. Dr. Morton and Mr. T. A. Conrad, of Philadelphia, had very thoroughly examined and described the fossils of the southern section of the State. The published results of

these labors are among the most valuable contributions to science that this country has afforded, and will stand as monuments to the high scientific attainments and indefatigable industry of their authors.

During the past three or four years, many detailed local examinations have been made in the mineral regions of the State by eminent scientific men, which have resulted in very valuable discoveries of new minerals and natural fertilizers. But as the investigations have been made solely for the advancement of private interests, the people at large have been but little benefited thereby, and indeed have frequently parted with valuable property in mineral districts for a trifling consideration; things which would not have occurred had they been possessed of such reliable information as a detailed geological survey would have afforded.

At the time of the last geological survey, very little attention was paid to the importance of the application of chemical and geological researches to agriculture. The State was comparatively thinly settled, and the average quantity of rich virgin lands being very great in proportion to the inhabitants, its necessity and value were not so apparent as at the present time, when a constant tide of immigration is densely populating its territory, and the once rich lands are becoming impoverished by an exhausting system of tillage.

MINERAL RODS, HAZEL WITCHES, FOOL'S GOLD, SEARCHING FOR GOLD.

The frequent applications that have been made to me for the loan of divining or mineral rods, either for the purpose of discovering the hidden treasures that lie concealed beneath the surface of the earth, or for reaching some vein of gold, silver, or copper, of which a traditionary account has been handed down from generation to generation, or for exploring the spot where a flash of light has been seen, or an explosion heard—which by many are believed to be infallible signs of the oc-

currence of minerals; and the experiments which I have witnessed of the use of the hazel witch, for the purpose of locating wells where the water runs nearest to the surface, suggest the propriety of making some remarks by way of caution to those who believe in the efficacy of such means.

In my travels through the State, hardly a day passes on which such applications are not made to me, together with the recital of wonderful discoveries which have been made through such instrumentalities. It is not indeed wonderful, that there is so much credulity among the great masses of the people, for they have but little knowledge of the properties of minerals, or of the elementary principles of natural science. It seems to them as reasonable to believe that the presence of gold, silver or copper may be indicated by some such instrumentality, as that a vein of magnetic iron ore may be discovered by means of the magnetic needle. In order that I may give a clearer idea of the manner in which many people of this State have been duped, I will briefly mention a few cases that have come under my own observation.

Two years ago, a very worthy and respectable man called upon me, stating that he supposed I had a mineral rod that would discover a vein of copper, its depth from the surface, its width, and the quality of the ore, and that he would like to borrow it for the purpose of finding a vein of copper in Morris County, which his grandfather had discovered some sixty years ago, and some of the ore from which he had smelted in a blacksmith's forge in the vicinity. He stated that his grandfather had moved to Missouri when his father was a boy, and had often told his son of this copper vein, giving to him before his death a map of the property, upon which was indicated the precise spot where the opening had been made into it. He felt so confident that by means of this map he could go directly to the concealed treasure, that he endeavored to purchase the property at a very high price. On arriving at the premises in question, he was unable to find the opening into the vein, on account of the changes which cultivation had wrought upon the fields. He immediately applied to a man

in the vicinity who possessed a mineral rod of marvellous virtue, and who professed to be skilled in its use; told him his story, and, after receiving from the mineralist assurances of the occurrence of a copper vein in that field which his mineral rod had discovered several years previous, offered to disclose it to him, together with its precise width, richness, &c., for the sum of twenty-five dollars. The stipulated sum being soon paid, they proceeded to the field; the mineral rod pointed out the vein, the dimensions of which were duly defined with stakes. So well satisfied was he with the correctness of the revelations of the magic rod, that on the following day he offered to purchase the property at ten times its value. The owner, however, catching the enthusiasm and dreaming of becoming suddenly rich, would not dispose of his property under any circumstances; but offered to lease it on very favorable terms. A lease was accordingly drawn, and our hero distributed operations by sinking a shaft over the supposed vein; and when he applied to me had already sunk the shaft twice the depth required by the revelation; and having expended several hundred dollars, was about returning to the West either to induce his father, an old, feeble man, to come and point out the spot, or to recruit himself with funds to prosecute the work.

During the last summer, I met with one of these philosophers in whose hands the divining rod possesses such wonderful powers, and who has acquired great reputation in the northern part of the State, not only from the pretended discoveries that he has made, but for his untiring efforts to unfold *hidden treasures*. After much difficulty, my curiosity was gratified by seeing the veritable rod with which, according to his own statement, he had located the principal gold mines of Virginia and North Carolina, had discovered sunken steamboats on the great lakes, had told how much silver there was in the Sussex Bank, had traced the franklinite and zinc ores of Stirling Hill for miles from their present location, had discovered the principal iron veins of New Jersey, and for which he had been offered two hundred thousand dollars by a company in California.

The instrument resembled an ordinary metallic syringe, about one inch in diameter, and five or six inches in length, having screws attached to the larger extremity, by which it could be fastened to the handle of a cane. He stated that it was made of silver, and that its virtue depended on a peculiar substance which he had discovered, and which he placed in the syringe, when he wished to search for silver ore. These instruments were made of different materials according to the metal sought; for example, if the object of his search was gold, he used one made of that metal, and charged in the same manner: if he sought iron, his instrument was of iron, &c. When on his exploring expeditions, he carried with him a number of them. He never allowed them to go out of his hands, as their magic influence would thus be at once destroyed. I was very much amused by his company during a short trip over the Sparta Mountain, when he promised to point out to me the precise locality of the franklinite and zinc veins crossing this region. He informed me, in different places, as to the precise number of feet and inches at which these veins lay from the surface; and after showing several small bowlders of zinc and franklinite ore lying on the surface of his vein, he observed: "a good many scientific geologists have been around here, who think they know every thing about minerals and so on, and they say that these are loose pieces that have travelled from the mine at Stirling Hill, but it ain't so; it's agin' nater for stones to swim or run up hill."

I would not have repeated so much of his jargon, had I not been informed that during the past three or four years he has received eight or ten thousand dollars for his professional services in that vicinity, and that a large amount of money has been expended in digging under his directions.

Water philosophers, or those who profess to be able, by means of the *witch hazel*, to discover springs and streams of water beneath the surface, are somewhat numerous throughout the State, and are often called from some distant place to decide upon locations for digging wells. I had an opportunity of witnessing the operations of one of them in locating a

stream of water, and determining its depth, capacity, &c.; but in regard to the correctness of his statements I had no visible evidence.

One of the most common delusions, and one that has caused a great expenditure of money, is the flashing of lights and rumbling noises, concerning which many notions are entertained. During the past summer, I found men on the Blue Mountain digging for gold in the hard Shawangunk grit, where lights were said to have been seen; and numerous are the excavations that have been made there in search of gold, solely on account of some traditionary tale about the appearance of fire or smoke. Among the inhabitants of that mountain there is hardly a man who has not heard of lights and rumbling noises. In several of the excavations I found iron pyrites, which, by a rapid decomposition, sometimes produces a great deal of heat and even smoke; and if lights have ever been seen, their origin can be referred to the pyrites. For the information of those who are so credulous in such matters, I may be allowed to say that they are no indication of valuable mineral deposits.

The occurrence of iron pyrites, to a greater or less extent, in almost all the rocks of the northern part of the State, has been the cause of a useless expenditure of money. On account of its resemblance to gold in color, and the frequency of its being mistaken for that mineral, it has been called "fool's gold." Many have sought me with parcels of it carefully wrapped in paper, which they had obtained at an expenditure of much labor and money, and have asked its value, together with advice as to the best method of continuing their work. It may be readily distinguished from gold by holding it in the flame of a candle or throwing it in the fire, when it will lose its brilliant hue; while gold, under the same circumstances, will preserve its color. It may also be detected by its brittleness; for if the point of a knife be pressed against it, it will break readily, while gold is tenacious and difficult to be broken.

The frequent occurrence of dark-colored slates and shales

along the Delaware River, and east of the Blue Mountain, has induced many to believe that coal must be associated with them; and many excavations have been vainly made in search of it. It often happens that coal miners, passing through the country, assert the presence of coal in these districts, on account of the similarity existing between the shales here and the slates of the coal mines in which they have worked. These men are not unfrequently employed to dig for coal. But so far as the geological researches have extended during the past year, it is ascertained that no coal exists there.

I think it may be safely said that the money expended in idle researches at the instigation of pretenders, or from a lack of information respecting the natural resources of the State, would be more than sufficient to complete the survey, and thus afford reliable information to every one of its inhabitants.

We are apt to wonder at the credulity of our forefathers in their belief in the magician's wand and the philosopher's stone, but nowhere in history have we accounts more absurd than those furnished in our very midst. In fact, there has always been a kind of superstitious feeling or credulity respecting the precious metals, and I know of no better way of dispelling it than by the promotion of education, and the dissemination of useful knowledge, in which New Jersey is now taking a very creditable stand, by the establishment of a liberal system of instruction, and by carrying on extensive internal improvements.

PLAN OF SURVEY.

The plan adopted for prosecuting the survey, and by which it has been conducted during the past year, divides it into four principal departments, viz.:

1. The Trigonometrical and Topographical.
2. The Geological.
3. The Palæontological.
4. The Chemical and Mineralogical.

TRIGONOMETRICAL AND TOPOGRAPHICAL DEPARTMENT.

On referring to the accompanying report of Mr. E. L. Viele, the State Topographical Engineer, it will be observed that this part of the survey has been vigorously prosecuted. When we take into consideration the limited means placed at his disposal for properly commencing the work, the many difficulties under which he labored at the outset, and the lateness of the season, it will be seen that much has been accomplished. It will be remembered that the object of this part of the survey is to furnish a detailed and accurate topographical map of the State, upon which its geological features may be correctly delineated, and from which sections may be made representing the thickness and superposition of each formation of rocks; and as this is the groundwork of the geological survey proper, the greater part of the funds placed at my disposal has been appropriated to its prosecution, in order that as much of the topography might be completed as possible by the opening of the next year, which being mapped out during the winter, would serve as a guide in the detailed geological examination for that year. Independent of the great importance of this survey, on account of its connection with geology, it will be of incalculable benefit in various respects. It will furnish a map upon which every mountain, hill, and valley, with their comparative dimensions, every boundary line, natural and artificial; every road, river, stream and canal; every farm and house, will be represented. By it, public works may be plotted, and systems of drainage established. It will be of great benefit in the opening of mines, quarries, and deposits of fertilizers.

GEOLOGICAL DEPARTMENT.

In the geological department two divisions of the State have been made: Northern and Southern. The line of division extends from Staten Island Sound near Elizabethport

to the Delaware River, a little below Trenton, following the southeastern border of the red shales and sandstones which stretch across the central part of the State. This line has been selected on account of its being a natural division of the State into two nearly equal parts, in respect to area, while in respect to their physical, geological and agricultural features, they are entirely different. The adoption of this division will, in the final report, be the means of avoiding unnecessary repetition.

SOUTHERN DIVISION.

The southern division of the State has been assigned to Professor George H. Cook, assistant geologist of the survey. He entered upon his duties in Monmouth County on the 27th of July last, and from that time to the present has been engaged either in the field or in the laboratory. His attention has been chiefly directed to the marl beds of the greensand formation; and a perusal of his report will satisfy all of the great importance of a more minute examination than has hitherto been made. Allow me to call your attention especially to that part of his report which refers to the following facts, proved from examinations in the field:

1. "The clays and marls which constitute the basis of most of this part of the State are in regular and continuous layers."

2. "The layers are not level, but incline or dip towards the southeast."

3. "Since those layers were formed, the action of the water, or other causes, has worn away and changed the surface of the country."

Laying aside for the present, the importance of these facts in a scientific point of view, I will merely refer to their practical application.

Although the layers of marl, constituting this formation, are not level, yet they are deposited in a certain plane whose inclination is towards the southeast. The irregularities of the

surface of the soil having been produced subsequently to the deposition of the marl layers, by the action of currents of water, winds, &c., it is evident that these irregularities are entirely independent of the surface of the marl layers. Knowing then the inclination of the layers of the latter, and adopting their surface as a base, we may, by measuring the inequalities of the surface across the formation, ascertain the precise depth of each bed of marl from the surface, and represent it by means of maps and sections; thus each landholder within the formation can determine the most accessible localities for opening marl pits. Hitherto the discovery of marl pits has been uncertain and accidental, on account of a want of that accurate information respecting their position, division into distinct layers characterized by particular fossils, and their position relative to the surface configuration. If, then, land upon which marl is accessible is worth from five to seven dollars per ten feet square upon the surface, and scientific investigation determines where such lands may be located within the five hundred and seventy-six thousand acres of this formation, it is superfluous to enlarge upon the great benefits to be derived from it.

NORTHERN DIVISION.

To the geological examination of the northern division of the State, I have given my own personal attention, and the results thereof will be seen in the sequel to this report.

PALÆONTOLOGICAL DEPARTMENT.

This being one of the most essential branches of the science of geology, I directed, at the commencement of the survey, each member of the corps to pay particular attention to searching for, gathering, and preserving organic remains. The result is, that quite a large collection of the fossils of Sussex and Monmouth counties has been made and forwarded to the State

capital, as well as to the county seats of the counties in which they are found. The collection from each formation being still incomplete, and the time very limited, it is deemed inexpedient to make any description of the specimens already procured until a subsequent report. I would recommend a vigorous prosecution of this very important department of the survey, so that upon its completion, every species of organic remains found in the State may be accurately described and represented.

CHEMICAL AND MINERALOGICAL DEPARTMENT.

Mr. Henry Wurtz, the chemist and mineralogist of the survey, entered upon his duties on the first day of November last. In order that the chemical investigations of some of the most important minerals and fertilizers might be made at as early a day as possible, I directed him to rent a building suitable for a laboratory at Trenton, and to proceed at once to furnish it with the necessary apparatus and reagents. The amount of funds set apart for this purpose being wholly insufficient, Mr. Wurtz has, by adding his own apparatus and chemicals, formed a very complete and convenient laboratory, and already made some chemical investigations of the fresh-water marls and calcareous sinters of Sussex County, the results of which will be found in his accompanying report. Prof. Cook has also been engaged in his laboratory at Rutgers College, in making examinations of the greensand marls, and the results of his researches will be found to be of very considerable importance.

CABINET.

The law authorizing the survey provides for the collection of two complete suites of specimens of all the different minerals, rocks, fossils, marls, clays, sands, peats, &c.; one to be forwarded to Trenton, to be disposed of as the Legislature may hereafter direct; the other, consisting of the minerals,

&c., peculiar to each county, to be forwarded to the county seat, and there disposed of as the Board of Freeholders shall deem proper. As far as the researches have extended in detail, three suites have been made, two for Trenton and one for the county seat. I think it advisable that two suites should be made for the State, in order that the final arrangement of the cabinet may be divided into two parts, viz.: a geological and geographical arrangement. The former to exhibit the rocks in their order, together with their associate minerals, fossils, &c., corresponding with the geological maps, sections, &c.; the latter a local arrangement in townships, or sections of townships, to correspond with the accompanying local descriptions. I propose to adopt the latter alone for the county cabinets.

During the year twenty-six boxes of rocks, minerals, and fossils have been forwarded to Trenton from Sussex County, and eight to Newton. Prof. Cook has made a complete collection of the marls of Monmouth, as far as his detailed examinations have extended. They have been properly prepared and labelled, and now await a suitable place for their reception. The very great variety of minerals and organic remains of this State, will necessarily form an extensive cabinet, and I would therefore call the attention of the Legislature to the importance of taking some steps towards obtaining suitable rooms for its permanent arrangement. I would also here state that several applications have been made to me by different educational institutions in this, as well as in other States, for complete collections of New Jersey minerals, rocks, &c. But as much expense attends the collection of specimens, and as the law does not authorize more than two suites, I could not comply with any of these requests. It is very desirable, however, that a knowledge of the resources of this State should be spread as widely and rapidly as possible, and there is no more effectual way than by distributing samples of its productions to every part of the country. The subject is worthy of the consideration of the Legislature.

EXPENSES OF THE SURVEY.

Upon organizing a competent corps, consisting of an engineer, assistant geologist, chemist, and mineralogist, and other aids sufficient to commence and carry on the survey in accordance with the adopted plan, a difficulty was encountered at the outset, on account of the smallness of the appropriation.

Reconnoissances were to be made, instruments, apparatus, and chemicals to be provided and transported, and a variety of preliminary arrangements required, as may readily be expected at the opening of a work of this kind. It was evident that to commence the survey on this plan, in all the departments, not only a rigid economy must be observed, but that the greater part of the necessary instruments must be obtained otherwise than by purchase. With this view, letters were addressed to Prof. Bache, superintendent of the United States Coast Survey, laying before him the embarrassing circumstances under which we labored, and soliciting the loan of certain instruments. Prof. Bache, convinced of the great importance of the undertaking, responded unhesitatingly to our solicitations, and forwarded all that we needed; the acknowledgment of which, together with the acknowledgment of the receipt of instruments from the New Jersey Franklinite Company, will be found in the accompanying report of the topographical engineer. Each member of the corps also loaned his instruments and apparatus, and thus a great expense was avoided at the outset.

As several applications had been received from young men desirous of becoming connected with the survey, for the purpose of acquiring practical knowledge in the several departments, it was thought advisable to receive all such as volunteers, who should be willing to bear their own expenses, and have assigned to them a particular duty, to which they should attend as assiduously as if they were compensated. At different times during the year, eight have been received upon these terms; and although an acknowledgment is due to some

of them, yet, as a general rule, I do not think the plan is an economical one; for in every department of the survey, it is necessary that each member of it should know his duty, and attend to it zealously. The applicants or volunteers are chiefly young men, who have just completed their collegiate education, without any fixed business habits, and in some cases unsettled as to the choice of a profession. They enter upon the survey, and in a few weeks, becoming dissatisfied, desire to try some other department. The result is, that the party becomes disorganized, operations temporarily suspended, until a reorganization can be made; and thus, indirectly, a greater expense incurred than would compensate competent assistants. In making the above remarks, I do not wish to convey the idea that such has been the case with all the volunteers who have been engaged in the survey. Some of them have been of much service to the State, and I trust have received in return much useful and practical information. This statement I am induced to make on account of the numerous applications for such situations, as well as for the purpose of removing the impression received by many, that such services must diminish the expense of the survey.

The following is an abstract of the disbursements in prosecuting the survey for the year ending December 31, 1854:

For services,	$3,680 10	
" instruments and apparatus,	133 50	
" incidentals,	186 40	
Amount,	$4,000 00	
Appropriation for survey, made March 2d, 1854,		$4,000 00

ESTIMATE OF EXPENSES FOR THE YEAR EIGHTEEN HUNDRED AND FIFTY-FIVE.

The following is an abstract of the expenses for prosecuting the survey in an expeditious and economical manner, for the year eighteen hundred and fifty-five:

Trigonometrical and Topographical department,	$15,000
Geological Department—Southern Division,	2,000
" " Northern Division,	4,000
Chemical and Mineralogical department,	2,500
Palæontological department,	1,500
	$25,000

With this amount the topography can be extended over the greater part of the State; the geological researches made in detail as far as the topography extends, together with a general examination of the remaining portion, leaving the survey in such a condition that the entire field work of the State can be completed in eighteen hundred and fifty-six.

In the preceding pages, I have endeavored to present a general outline of the manner of prosecuting accurate geological surveys, and of the plan upon which the survey of this State has been commenced and carried on, the amount of time and means for completing it, and the benefits to be expected therefrom. I trust that the Legislature will take the matter fully into consideration, and that an ample appropriation will be made towards its rapid completion. The geographical position of the State, its varied physical aspect, geological formations, and soils, demand that every acre of its territory should be thoroughly examined. There was a time, in the infancy of the science of geology, when general investigations were deemed sufficient to answer all practical purposes. That time has passed away; economical geology has become an accurate science, and in order that the most beneficial results may be attained from its investigations, it must be pursued in an accurate manner.

SEQUEL TO NORTHERN DIVISION.

I have devoted the greater part of my time, from the middle of July to the first of December, to geological examinations of the northern division of the State. During this time I have made a reconnoissance of Sussex County, and a part of

Morris and Passaic counties; also detailed examinations of the townships of Sparta, Hardiston, Vernon, Wantage, Montague, and a part of Sandiston and Newton. Several geological sections have been made from actual measurements and levelling across the country from the Delaware River to the Highlands; also sections, on a greater scale, of important mineral localities and mines, representing the relative position, thickness and dip of each kind of rocks, and their associated ores. Twenty sketches, illustrating the physical features of the surface, and geological peculiarities of the rocks, have been taken, and will be submitted for the inspection of the Legislature. The sections, profiles, and sketches, are intended to accompany the final report.

Thirty-four boxes of minerals, fossils, marls, peats, &c., have been collected, and forwarded to Trenton for examination, labelling, &c. But since the close of the field labors, there has not been sufficient time to make such an examination as is necessary before an accurate and complete report can be rendered on any particular locality or formation. I shall therefore only give a synopsis of such results of the investigation as may be particularly useful, and shall confine myself to that part of Sussex County in which the more detailed researches have been made.

GENERAL REMARKS ON THE PHYSICAL GEOGRAPHY AND GEOLOGICAL FORMATION OF SUSSEX COUNTY.

The physical geography of Sussex County, indeed, that of the whole northern division of the State, presents a striking contrast to that of the southern division; for while the latter resembles an extended plain, offering but little to attract the attention of the traveller, except its fertile fields and evergreen forests, the former is diversified with mountains, hills and valleys, affording that beautiful and varied scenery so characteristic of mountain districts.

There are three principal ranges, or series of elevated lands,

crossing the county in a northeasterly and southwesterly direction, viz.: the Blue or Kittatinny Mountain, extending along the northwestern boundary of the county, from the State of New York to Pennsylvania; the series of hills or ridges forming the Pochuck Mountain and Pimple Hill; and that part of the Highlands known as the Wawayanda, Wallkill and Andover Mountains, stretching along the southeastern border of the county.

Corresponding with the mountain ranges are three valleys, viz.: the valley of the Delaware, situated between the foot of the northwestern slope of the Blue Mountain and the Delaware River; the Kittatinny valley, ten miles in width, extending from the southeastern base of the Blue Mountain to the Pochuck and Pimple Hill range; and the valley of the Wallkill, situated between the latter and the Highlands. While the mountains are characterized by a rocky, meagre, and unproductive soil, and covered with trees of various species, and thickets of scrub oaks, the valleys are fertile, with a soil of alluvial and diluvial origin, easily cultivated, and bountifully rewarding industry.

The mountains, valleys and plains, are watered by numerous springs, lakes and rivers. The former are every where to be found on the elevated lands; and this, together with the peculiar adaptation of the soil to the growth of grass, renders the country admirably fitted to the rearing of fine stock, for which it is somewhat celebrated.

The numerous lakes, situated upon the highest lands, form a striking feature in the physical aspect of the country. They are sometimes one mile, sometimes several miles, in length and width; and they abound in the choicest varieties of fish. Among them may be mentioned the Wawayanda Lake, located upon the mountain of the same name, and which is a beautiful sheet of water about two miles in length, half a mile in width, and from ninety to one hundred feet in depth; the Machipaconk Lake, on the Blue Mountain, three quarters of a mile in length and half a mile in width; Cedar Swamp Lake, on the Blue Mountain, near the New York State line, and

thirteen hundred feet above the level of the water in the Delaware; Culver's, Swartwout's, Long, Morris's, and numerous other lakes.

The streams take their origin chiefly in the central part of the county, and empty their waters into the Hudson and Delaware rivers. Among them may be mentioned the Little and Big Flatkill, Paulin's Kill and Pequest, whose waters are emptied into the Delaware; and the Wallkill, with its numerous tributaries, as the Wawayanda, Warwick, Black, and Papakating creeks, emptying into the Hudson.

Its geological formations are as varied as its physical features. From the earliest period of the earth's existence, the two great dynamic forces, the igneous and the aqueous, have here alternately exerted themselves in forming and modifying its surface. At one time the waters of the ocean, teeming with animal life, covered its whole extent, and deposited the materials which now constitute its sedimentary rocks. At another time igneous agencies upheaved them from their ocean beds, forming the mountains and the valleys, filling the sedimentary deposits with rich ores and minerals, and thus here bringing together the three principal classes of rocks: aqueous, metamorphic, and igneous.

The aqueous rocks consist of a series of blue limestones of various shades of color, texture and composition; argillaceous, silicious, and calcareous slates and shales, and red, white, and gray sandstones, grits and conglomerates. They are composed of those series of rocks, denominated by the geologists of the New York survey, the New York System; and correspond with the Devonian and Silurian Systems of the English geologists. The most recent, or uppermost of this series, is a black fissile slate, called Marcellus Slate, the oldest member of the Erie Division of the New York System. This rock has but a very limited range in this State, occupying a bend of the Delaware River, which extends only three quarters of a mile below Shabacong Island; it then disappears beneath the alluvial matter of the island, and of the valley of the Delaware. Its greatest width is three hundred yards. It may be examined

on the farm of Peter Van Noy, about a quarter of a mile from the river, where a tunnel has been made in search of coal. Its color is very dark—almost a jet black; it is very fissile, and under the stroke of the hammer, it breaks into small pieces not greater than six or eight inches across. It contains iron pyrites, which on the exposed surface of the rock, having decomposed and covered it with an incrustation of the hydrous peroxide of iron, gives to it a brownish iron-rust color. A considerable quantity of this iron-rust, or hydrous peroxide of iron, has been carried down by streams of water and deposited along the banks of the river, and thus led many, erroneously, to believe that valuable deposits of iron ore are located in the vicinity.

The next series of rocks in the descending order, upon which the Marcellus Slate reposes conformably, is the Helderberg Series. This division embraces a series of limestones, varying in their lithological, chemical and fossil characters, by which they are subdivided into beds. Among the subdivisions occurring in this State which are well developed, and may be accurately defined by their characteristic fossils, may be mentioned (taking them in their order), the Corniferous, Onondaga, Encrinal, and Delthyris Shaly limestones, and Water Lime Group. They all abound in fossil remains; the most abundant being the encrinal, coralline, and testaceous remains; and each subdivision has some that are characteristic of it. They extend along the Delaware River from the New York State line to Walpack Bend, and vary from one mile to a mile and a half in width, composing that series of rolling hills and fertile ridges situated at the northwestern base of the Blue Mountain.

Directly under the Helderberg Series occurs the Ontario Division, of which the Medina Sandstone is well developed here (No. V. of Prof. Rogers), consisting of dark red sandstones and shales, occupying the northwestern slope of the Blue Mountain.

Next in the descending order occurs the Champlain Division, of which may be mentioned the following subdivisions:

1st. The Oneida, or Shawangunk Conglomerate, occupying the elevated portions of the Blue Mountain, and which is composed of a series of fine-grained silicious grits, coarse sandstones, and conglomerates made up of silicious matter from fine sand to pebbles of quartz three quarters of an inch in diameter; the Hudson River Group, composed of dark-colored slates, shales, thick-bedded and slaty calcareous grits, &c.; the Utica Slate, composed of dark-colored and argillaceous slates, furnishing in many places an excellent material for roofing; the Trenton and Black River Limestones; Calciferous Sand Rock, and Potsdam Sandstone. The above subdivisions of the Champlain Series, commencing with the Hudson River Group, occupy chiefly the Kittatinny and Wallkill valleys.

The metamorphic rocks are gneiss, hornblende slate, and white crystalline limestone. The latter occurs chiefly in the valley of the Wallkill, between the Wawayanda and Wallkill mountains, and the Pochuck and Pimple Hill range; the two former constitute the principal part of the rocks of the mountain ranges, as well as several parallel belts of the Wallkill valley.

The igneous rocks occur chiefly in the form of intrusive veins, dikes, and irregular masses of granite, syenite, and quartzose feldspathic rock, in the metamorphic, with the exception of a porphyritic granite which occurs protruding through the Hudson River Slate, and upheaving the Oneida or Shawangunk Conglomerate of the Blue Mountain near Beemersville, five miles northeast of Culver's Gap.

ECONOMIC GEOLOGY.

Among the various ores and materials of economical value occurring in the above formations are:

Magnetic iron ore;

Specular iron;

Limonite (hydrous peroxide of iron);

Iron pyrites;
Franklinite;
Red oxide of zinc;
Galena (argentiferous);
Sulphate of baryta;
Roofing slate;
Limestone for building and agricultural purposes;
Marble;
Calcareous sinter;
Shell marl;
Peat;
Kaolin (porcelain clay).

MAGNETIC IRON ORE—MAGNETITE—MAGNETIC OXIDE OF IRON —NATIVE MAGNET—LOADSTONE.

This ore, when pure, has an iron black color, and metallic lustre; is strongly magnetic; produces a black streak when rubbed on a surface of unglazed white porcelain, and gives a black powder when pulverized. Its composition is oxygen and iron—a combination of the protoxide and peroxide—72.4 of iron and 27.6 of oxygen. It may be readily distinguished from other ores of iron by its black streak and powder, and magnetic properties.

The description here given is that of pure magnetic iron ore, but this substance is very often associated with foreign matter, as quartz, mica, hornblende, feldspar, etc., which alter the color and general character of the ore, according to the kind, quantity, and texture of the foreign matter. It is one of the most valuable ores of iron; and from it the greater part of the iron of this State is manufactured. It occurs in veins and beds, and is disseminated through igneous and metamorphic rocks. In this district it occurs chiefly in the igneous and metamorphic rocks of the Highlands, and valley of the Wallkill.

The following are among the most important localities:

WAYWAYANDA MINE.

This mine is situated on the Wawayanda Mountain, half a mile from the New York State line, and two and a half miles northeast of the Wawayanda Lake. The prevailing character of the rock, in which the ore occurs, is gneiss. It is exceedingly variable in composition and texture. Mica enters but slightly into any of the rocks throughout the whole mountain, and in many places it is entirely absent. When entirely absent, hornblende, or magnetic iron ore, in grains, takes its place, forming a syenitic gneiss. The rock in some places is composed only of feldspar and quartz, the former being its principal ingredient.

Four deposits of ore have been opened and worked. Their prevailing course is northeast and southwest, and their dip from twenty to forty degrees to the southeast.

Commencing at the southeasterly deposit, and taking them in their numerical order, we find that the first is not worked at the present time, and has not been for several years, because the ore is more accessible and more abundant in the other deposits. On account of the water in the shaft, and the dilapidated condition of its timbering, I was unable to make a personal examination, but I was, however, informed by the mining captain, that it has been worked to the depth of one hundred and ten feet, and one hundred on the deposit; and that the ore is from twelve to fourteen feet in width, at the bottom of the shaft.

The second deposit occurs fifty feet northwest of the first. It has been worked to the depth of eighty feet, and one hundred feet on the deposit; and at its present depth is thirty feet in width.

The third deposit is seventy-five feet from the second. Here the ore occurs in the form of a bed, or irregular deposit, varying from two to twelve feet in width. At its present depth, one extremity of the workings shows the ore six feet in width, and the other two feet.

The fourth deposit, forty-five feet from the third, is from four to five feet in width, and has been worked to the depth of sixty-five feet.

About a quarter of a mile southwest of the Wawayanda Mine, on the property of Mr. Green, openings have been made into the third and fourth deposits, from which a large quantity of ore has been taken. All these deposits are exceedingly irregular, having no well defined walls. They occur between two strata of gneiss of different characters. The underlying stratum is generally a very hard and crystalline syenitic gneiss; the overhanging is chiefly composed of feldspar and quartz; the former in large imperfect crystals and greatly predominating. They are frequently displaced and altered by dikes of granite, which in some cases are injected into the deposit, and in others, cut it off entirely and throw it aside. Numerous sketches and sections illustrating the dislocations have been taken, and will accompany the detailed description of this mine in the final report, together with the composition of the ores, metallurgy, etc.

The ore from this mine is of an excellent quality, a large proportion of it being entirely free from foreign substances. It is highly magnetic, and possesses polarity. Iron pyrites sometimes occurs in very small quantities at the junction of the dikes and ore, which renders them easy of separation. It is chiefly smelted in a charcoal furnace upon the borders of Wawayanda Lake, and produces an iron peculiarly adapted to the manufacture of car wheels. Almost all of it is consumed by Whitney & Son, of Philadelphia, for this purpose. The mine and furnace are owned by Oliver Ames & Sons, of Boston, who commenced operations here about nine years ago. Until January last the work had been suspended for about four years, and since this time has been carried on with great activity.

Following the course of the Wawayanda Mountain towards the southwest, indications of the existence of magnetic iron ore are every where visible. In some places it is disseminated in grains through the rock, forming one of its constituent min-

ores; in others it occurs in "strings," or small veins, from one to several inches in width. In some places, large deposits are indicated by the magnetic needle.

OGDEN MINE.

The next important deposit of magnetic ore which has been opened and worked, is upon the Wallkill Mountain, three miles southeast of Franklin Furnace. It was opened in the year 1772 by Abram Ogden, and has since then been worked, at intervals, by different parties, its name always changing with the name of its proprietor. It has been known, at various times, by the name of Kinney's, Sharp's, and Bird's Mine. At present it is owned by the New Jersey Franklinite Company, and worked by Edward De Camp, of Charlottenburgh, whose name it bears. The ore occurs in the form of an irregular vein or deposit varying from ten to thirty feet in width. Its general course is northeast and southwest, and its dip is at an angle of ten degrees to the southeast. It is now worked forty feet from the surface, and is fifteen feet in width. The ore which it yields is of a variable quality, some being entirely free from foreign substances, while with a large proportion of it may be found the constituent minerals of the gneiss, and, in some cases, iron pyrites in small quantities. This ore is smelted in Hopewell Forge.

VULCAN MINE.

This mine is situated on Vulcan Head, on the property of Richard R. Morris, Esq., about half a mile southwest of the Ogden Mine. Two deposits of ore have been opened by means of shafts sunk to the depth of thirty feet. The first shaft exposes a mass of ore ten feet in width, dipping towards the southeast at an angle of fourteen degrees. The ore is highly magnetic, and contains a considerable quantity of feldspar and iron pyrites associated with it. The second shaft

exposes a mass of ore nine feet in width, associated to a considerable extent with grains of quartz and feldspar; but free from iron pyrites. Small specks of carbonate and sulphuret of copper are disseminated through some parts of it, but not in a sufficient quantity to injure it as a furnace ore, for which it will answer an excellent purpose.

Following the summit of the Wallkill Mountain towards the southwest, I observed many indications of large deposits of ore. Undoubtedly very extensive beds may be opened in this vicinity, which at no distant day will prove a source of great profit to their proprietors.

SHERMAN'S MINE.

This mine is situated on Slack Brook, three quarters of a mile southeast of Sparta. Several deposits of ore are exposed on either side of the brook, varying from three to ten feet in width. They are very irregular, having no well defined walls, and, in many places, it is difficult to ascertain their limits, because the ore is disseminated to a considerable extent through the adjoining rocks.

SPECULAR IRON—PEROXIDE OF IRON—RED IRON ORE—RED HEMATITE.

This ore of iron, when pure, has a metallic appearance; is of various shades of color, and is composed of seventy metallic iron and thirty oxygen, in one hundred parts. It is easily distinguished from other ores of iron by its reddish streak and powder. In nature it rarely occurs in a pure state, but generally mingled with lime, silica, alumina, &c., when its value depends on the nature and proportion of the foreign material. It is generally found in beds or irregular deposits associated with igneous and metamorphic rocks, more frequently in the latter, or at the junction of the two. A great part of the iron manufactured in different countries is from this ore, and al-

though it requires much more heat to smelt than other ores, yet it produces an iron of excellent quality.

In this district this ore occurs in the white crystalline limestone, and is generally found at or near the junction of that rock with gneiss, syenite and granite. Large bowlders of it are found all along the southeastern border of the white limestone formation from the New York State line across the State to Pennsylvania. A careful examination of the district will undoubtedly be the means of developing extensive deposits of this valuable ore. Among the localities that have already been worked to a considerable extent, I will refer to but two, viz.,the Simpson and Andover mines.

SIMPSON MINE.

This mine is in Vernon Township, half a mile from Smithville, and two and a half miles northeast of Hamburgh. The ore occurs in the form of a bed or irregular deposit, from six to ten feet in width, in the white limestone. Excavations have been made into it to the depth of twenty feet, from which considerable quantities have been removed and smelted in the old Hamburgh Furnace, yielding an iron of superior quality. This ore has a brownish red color, a fine steel-grained texture, and a metallic lustre. A large proportion of it is quite pure and almost entirely free from foreign materials.

ANDOVER MINE.

This mine, celebrated as one of the oldest and richest iron mines in this country, is in the township of Newton, near the village of Andover, and in the same geological range and formation as the mine last mentioned. It has been worked at different times from the year seventeen hundred and sixty to the present, and is noted for furnishing an ore peculiarly adapted to the manufacture of steel.* The ore occurs in the

* Hon. Jacob W. Miller's address before the New Jersey Society, 1854.

form of a large irregular deposit, from sixty to eighty feet in width, and forms the southwestern side of a hill rising upwards of one hundred and fifty feet above water level, and from which during the last seven years over one hundred and twenty thousand tons of ore have been removed. The principal part of the ore is specular iron of different shades of red, gray and blue, and of various qualities. Its color, texture and lustre depend chiefly on the foreign materials with which it is mingled, among which are carbonate of lime, alumina, silica, magnesia, manganese, and magnetic oxide of iron. The following are the statements and analyses which Mr. James C. Kent, the chemist of the Trenton Iron Company, has, at my request, been kind enough to furnish me:

"OFFICE COOPER IRON WORKS,
December 15, 1854.

"The Andover mines, situated at Andover, Sussex County, New Jersey, were originally worked by an English Company prior to the Revolutionary War, from which period up to the year eighteen hundred and forty-seven, they remained unworked. In the latter year they were purchased by Peter Cooper, Esq., for the Trenton Iron Company, who have since continued mining, and, in seven years, have taken from them upwards of one hundred and twenty thousand tons of ore.

"The ores are principally the peroxide of iron, and the chief varieties are the 'blue' and 'red.'

"The following analyses, selected from a number I have made at different periods, give the composition of the varieties above mentioned.

	Blue.	Blue.	Red.	Red.
Peroxide of Iron,	90	70	65	70
Oxide Manganese,	3	2	4	10
Carb. Lime,		16	16	12
Silica,	6	8	10	6
Alumina,			2	
Magnesia,			1	
	99	99	99	99

"There are other kinds of ore occurring in smaller quantities. I subjoin analyses of the most interesting:

	Brown Ore.	Resinous Ore.	Carbo Silicate of Manganese.	
Peroxide Iron,	30	40	Protoxide Manganese,	34
Carb. Lime,	35	12	Lime,	11
Silica,	30	30	Silica,	33
Alumina,	3	3	Alumina,	1
Oxide Manganese,		15	Protoxide Iron,	1.5
			Carbonic Acid,	18
	98	100		98.5

"These ores, though not unusually rich, are remarkable for the facility and rapidity of their reduction in the smelting furnace.

"The large quantity of the best fluxing materials, such as manganese and carbonate of lime, contained in the ore themselves, renders necessary the small addition of but ten per cent. of fluxing matter in working the ores in the furnaces.

"In one of our furnaces (forty-two feet high and eighteen feet across the boshes), we have made two hundred and thirty tons of pig iron per week for six weeks in succession, with one and a half tons of coal per ton of iron; and the yield for a single week in one furnace has been as high as two hundred and fifty-one tons, an amount unprecedented in the annals of European furnaces. A considerable proportion of the iron produced is of the kind termed 'lamellated.' This iron is a type of the perfect combination of carbon and iron, with the carbon in larger proportion than in any other kind of iron. This species presents in the fracture a silvery brightness, and is beautifully crystallized, some of the crystals having brilliant faces, measuring two inches across. Another variety is the 'radiated,' which presents a fibrous fracture, the fibres radiating from the centre to the outside of the pig.

"The pig iron made at the furnace is puddled at the Rolling Mill of the Company, and the anthracite blooms thus made are converted into the various kinds of bar iron, rails, &c. At

the wire mills the blooms are worked and drawn down to the finest wire, unsurpassed in quality; steel of the best description is also produced from the iron; and when wrought iron of great strength and toughness is required, as in the shafts for our largest class steamers, the Andover iron has been thoroughly tested and pronounced unrivalled.

"The Trenton Iron Company have three furnaces at present in operation, requiring to supply them sixty thousand tons of ore per annum. A large proportion of this ore is taken from the Andover mines, yet notwithstanding this heavy demand upon them, the mines promise to yield for many years to come an abundant supply.

"JAMES C. KENT."

LIMONITE—HYDROUS PEROXIDE OF IRON—BOG IRON ORE—YELLOW CLAY IRON STONE.

This ore, when pure, is composed of the hydrous peroxide of iron, and contains about sixty parts of metallic iron in one hundred. It almost always occurs mixed with foreign substances, as lime, alumina, silica, &c., which give to it a variety of forms, and from which its name is derived. Its prevailing colors are various shades of brown and yellow; and its streak and powder are yellow brown. The variety called bog ore sometimes contains phosphorus, and yields a cold short iron, unfit for those purposes which require a tough tenacious metal, but admirably adapted for casting. This ore, in its various forms, occurs in beds associated with rocks of all ages. In this district the greatest deposits are found among the metamorphic rocks of the Wallkill Valley. Bog ore occurs, not unfrequently, in the Blue Mountains, and in the valley of the Delaware, but not in sufficient quantities to be of much practical importance.

On the farm of Chandler Wood, half a mile southwest of the New Turnpike, on the Blue Mountain, is a bed of this ore apparently of considerable extent. It is situated in a marsh at

the foot of a sandstone ridge. Its origin may be undoubtedly traced to the iron pyrites which abounds in the sandstones and grits of this mountain, and which, being decomposed, is carried down by the water, and deposited in the low, swampy lands situated at the base of the ridges.

POCHUCK MINE.

Two miles and a half northeast of Hamburgh, between the base of the Pochuck Mountain and a ridge of white limestone, occurs an extensive bed of brown hematite in stalactitic, mamillary and botryoidal forms, of a fibrous and massive structure. Excavations have been made on the surface, two hundred yards in breadth, and from sixty to eighty feet in depth, from which large quantities of ore have been taken, and smelted in the Hamburgh Furnace. The greater part of the ore occurs in concretionary masses embedded in clay and sand, also in beds of clay of various colors, which have been formed by the decomposition of a quartzose feldspathic rock. Large masses of a quartzose rock, of a honeycomb or cellular structure, containing fibrous limonite of a very pure quality, are associated with the above, having been apparently subjected to an intense heat. This mine has not been worked for a number of years, on account of great depression in the iron business.

EDSALL MINE.

Two miles northeast of Upper Hamburgh, another extensive bed of limonite has been worked. It is situated in a slight depression between the base of the Wallkill Mountain and a small knob of highly ferruginous feldspathic gneiss. Excavations have been made two hundred feet in length and breadth on the surface, and forty feet in depth. The ore is of the same general character, and associated with the same soft feldspathic rock as in the Pochuck Mine.

In following the course of the Wallkill Valley, along the base of the mountain towards the southwest, limonite may be seen in numerous places, mingled with the soil, indicating the existence of other beds, of equal extent and value, through this district. Examinations for this ore should be made at the base of the mountain, in depressions and valleys, and in the vicinity of the white or metamorphic limestone.

FRANKLINITE AND RED OXIDE OF ZINC.

Franklin and Sterling Hill in this district, have long been celebrated for the intricacy of their geological formations, their numerous rare minerals, and extensive and valuable metalliferous deposits. They have attracted men of science from all parts of the world, with a view to collecting specimens with which to enrich their cabinets, and to turning the inexhaustible quantities of franklinite and red oxide of zinc to some practical purpose. Although, from time to time, many attempts have been made to render them available for the manufacture of zinc, iron, or some of their compounds, it was not until within a few years that any favorable results have been obtained. These are among the most valuable contributions which have been made for many years to metallurgical science, and will be long regarded as illustrations of American enterprise and perseverance.

The nature of this report will simply allow the observation that the franklinite and zinc ores are among the extensive and valuable resources of this part of the State. Sketches, maps, sections, etc., illustrating their geology, mineralogy and metallurgy, have been carefully prepared, and will accompany full and detailed descriptions of them in a future report.

FRANKLINITE.

This ore occurs massive, of a compact, coarse and finely granular structure, also crystallized in octahedrons. It has an

iron black color, metallic lustre and a dark reddish brown streak and powder, and acts slightly on the magnet. It is composed of iron, manganese and zinc, containing, according to Berthier, of oxide of zinc, 17; of iron, 66; and of manganese, 16 parts; and, according to Dickerson, of oxide of zinc, 21.77; of iron, 66.12; of manganese, 11.99; and of silica, 0.13.

RED OXIDE OF ZINC.

This ore occurs in masses of a granular and foliated structure, also in grains mechanically associated with franklinite, and disseminated in white crystalline limestone. It has a dark red color, and orange yellow streak. When pure, it contains, according to Whitney, 19.74 oxygen, and 80.26 zinc in 100 parts, but it also contains a small per centage of oxide of manganese, to which its red color is ascribed.

These two ores have been found in no country but this, and in no region of it except at Franklin and Stirling Hill. Here they occur in extensive deposits, associated together, and connected with the white crystalline limestone. At Stirling Hill there are two of these deposits from three to fifteen feet in width. Their general course is northeast and southwest, and their dip forty degrees to the southeast. The red oxide of zinc, mechanically associated with franklinite, and, in places, disseminated to a greater or less extent through the limestone, occupies the upper portion of the deposit, while the lower portion is composed of grains and crystals of franklinite mechanically associated with willemite (silicate of zinc), disseminated through the limestone. The greater, or southeasterly deposit, occurs in a limestone bluff, which rises abruptly from one hundred and fifty to two hundred feet, forming a steep southeastern slope. It has been worked four hundred yards on its outcrop, in one place, on the property of the New Jersey Zinc Company, to the depth of two hundred feet. Near the surface, the zinc portion of the deposit was from two to three feet in width; at its present depth it is from six to eight feet in width, and

affords an excellent quality of ore. The franklinite portion of the vein is very irregular. In one place it is from fifteen to twenty feet in width, and of a remarkably pure quality; but, in either direction from this spot, it becomes thinner, and, in many places consists of a few crystals of franklinite very sparingly disseminated through the limestone. The second, or northwesterly deposit, has been recently opened on the property of the Passaic Company. It has been worked to the depth of about forty feet, and as yet does not exhibit the regularity found in the former. A tunnel is now being driven into the base of the hill, which will strike the deposit about ninety feet from its outcrop.

At the present time, two companies are engaged in mining the zinc ores of this locality, and in manufacturing directly therefrom the white oxide of zinc. The one is called the New Jersey Zinc Company, and the other the Passaic Zinc Company. The former was organized in 1848; and their works, situated in Newark, are in successful operation, producing annually between three and four thousand tons of the white oxide of zinc, which is sold as a paint, and is preferred for many purposes to white lead. A small furnace has been recently erected at their works, in which the refuse matter, chiefly franklinite, is smelted for iron.

The works of the Passaic Company have been recently established at Jersey City, where preparations have been made for manufacturing the white oxide on an extensive scale.

The only remaining locality at which these ores have been found, is at Mine Hill, in Franklin, where the franklinite greatly predominates over the other mineral. Two extensive deposits have been exposed, and worked to a considerable extent, crossing Mine Hill for a distance of three quarters of a mile in a northeasterly and southwesterly direction. They occupy the summit of the hill, which rises one hundred and fifty feet above water level; and to this depth the ore may be removed at a trifling expense. The following section on the southwestern slope of the hill, commencing at the northwest, and crossing the formations towards the southeast, represents the relative position of the two deposits of ore.

1. Syenite.
2. Magnetic iron, from two to six feet in width.
3. White Limestone, from four to ten feet in width.
4. Franklinite, twenty feet in width.
5. White Limestone, sixty feet in width.
6. Franklinite, twenty feet in width.
7. White Limestone.

The latter deposit of Franklinite (6) has been recently exposed for several hundred yards on its outcrop, exhibiting a mass of nearly pure ore, varying from twenty to fifty feet in width. At an opening in the deposit at the northeastern part of the hill, a considerable quantity of red oxide of zinc is mixed with the franklinite; as far, however, as the deposit is exposed, but very little zinc occurs. The magnetic iron ore (2) herewith associated, has been formerly worked to a great extent, yielding large quantities of excellent ore which was smelted in the old Franklin Furnace.

The New Jersey Franklinite Company, organized in 1853, is actively engaged in erecting furnaces and suitable buildings within a few yards of the deposits, for the purpose of smelting the ore, which will at the same time yield a superior article of iron as well as the oxide of zinc. One furnace is nearly completed, and will be put into operation in the course of a few weeks. The iron manufactured from the franklinite ore is of an excellent quality, and peculiarly adapted to the production of the best kind of steel. There are many circumstances which render Franklin an admirable location for the successful prosecution of an enterprise of this character. It not only furnishes an inexhaustible quantity of ore, but with the exception of fuel, every other article required in the manufacture of iron and zinc. Building materials of every description, including granite, marble and sandstones; clay for the production of bricks; limestone for plaster, masonry, &c., are in abundance. In addition to all these advantages, nature has here also furnished a never-failing water-power, by which operations of every kind may be greatly facilitated.

SHELL MARL—CALCAREOUS SINTER—CALCAREOUS TUFA—TRAVERTIN.

These terms are applied to deposits of lime from solution in water. They occur generally in springs, ponds, shallow lakes and low marshy lands. Water holding carbonic acid gas in solution, has the property of dissolving carbonate of lime, which is deposited in the form of a fine powder, whenever the carbonic acid gas escapes. This gas is held in solution by rain water, and many spring waters, which, in percolating through limestone rocks, or in passing over their surface, dissolve a portion of the lime, and carry it into ponds, lakes and marshes, where it is deposited in the form of a white calcareous powder. It is there absorbed and secreted by testaceous animals, whose outer covering, or shell, is thus formed. In those situations where a large quantity of calcareous matter is held in solution, these small testaceous animals grow in great abundance, and live but a short time, their places being taken by other generations, w ich in t rn die; and thus large deposits are formed, called *shell marl.* In those situations where but little calcareous matter is held in solution, new generations of testacea, in forming their own shells, consume those of pre-existing ones, and thus the rapid accumulation of shells is retarded. And, again, where a superfluous amount of carbonate of lime is held in solution, which is very often the case in limestone districts, the lime is deposited with the testaceous remains, which still more rapidly increases the deposits. Shallow ponds, or lakes, where the deposition of shells and lime is rapidly carried on, finally become filled up to the water line; so soon as the water passes off, peat begins to form, and by its annual growth and decay, a deposit of this material is quickly accumulated upon the marl. When in such cases, the peat begins to form on the surface, the testaceous animals do not cease to exist, but on the contrary, continue generation after generation to increase the deposit of marl under the peat, while at the same time the peat is continually

increasing upon the surface. It is in this form that extensive deposits of marl occur in almost every part of this county. Wherever such deposits have been examined, they are usually found to rest upon a bed of clay, sand or gravel, and are succeeded by muck or peat. At or near the junction of the peat and marl, a layer of living testacea generally occurs, mingled with the peat. From twenty-five to thirty inches below this, the living animals disappear, their places being occupied by their remains in a decomposed state. The shells most frequently found in these deposits are the Limnea jugularis, Valvata tricarinata, Cyclas similis, Planorbis bicarinata, and some other species.

Springs holding a large quantity of lime in solution, sometimes deposit it on the surface in the form of a loose porous mass. It often happens that twigs and leaves are enveloped in these deposits, and their impressions thus preserved in a most beautiful and perfect manner. Such deposits are called calcareous sinter, calcareous tufa or travertin. Extensive deposits of calcareous sinter and shell marl are found in every part of this county. The most important localities are in the limestone districts. A large deposit of shell marl is found along the course of Chambers' Mill Brook, in Montague Township, on the farm of Isaac Bonnell, Esq. This deposit covers an area of from seventy-five to one hundred acres. It is situated in a low meadow or marshy land, surrounded by limestone hills; and this meadow has, at one time doubtless, been covered by a shallow lake or pond. Near the centre of the deposit, an examination was made to the depth of eighteen feet, giving the following section:

Peat and muck, 3 feet.

Marl and peat containing living testacea, 4 feet.

Marl, very fine, made up of decomposed shells, 11 feet.

The instrument not being of sufficient length, the whole thickness of the deposit was not ascertained. In other places where examinations were made, the peat was found to be from five to ten feet in thickness; and from six to ten feet from

the surface, were found embedded the branches and trunks of trees from one to two feet in diameter.

On the Little Flatkill, two miles southeast of the town of Montague, upon the property of I. Cole, Esq., is found another deposit, covering an area of fifty acres. The peat resting upon the marl, is from four to six feet in thickness; and the marl from six to eight feet, resting upon a bed of sand and gravel. On the farm of Mr. Isaiah Vannetten, one mile and a half northeast of Hainsville, is another deposit covering an area of twenty acres, and overlaid by a deposit of peat from three to eight feet in thickness. On the farm of Mr. Benjamin P. Van Syckle, in Sandiston Township, three miles northwest of Tuttle's Corner, and two miles southeast of Dingman's Ferry, is found a deposit of calcareous sinter, covering an area of at least five acres. It is exposed on either side of a small stream to the depth of several feet. A well fifteen feet deep has been dug into it without passing through its whole extent. Though very hard and compact upon the surface, it becomes softer and more pulverulent as it descends. In it are found numerous nodules, or concretionary masses, which have been formed by the deposition of the lime around a twig or some other substance as a nucleus for the aggregation of calcareous particles. The source of this deposit may be traced to a spring, half a mile distant, near the house of Mr. James Struble. This spring issues from the base of limestone ridge, and empties into a small reservoir or pond, whence it passes to Mr. Van Syckle's land. In the bottom of this reservoir grows the Chara, a genus of aquatic plants. While growing at the bottom of ponds and streams, it has a dark green color, but upon being removed and exposed directly to the atmosphere, it soon becomes white and crumbles to a fine powder composed chiefly of the carbonate of lime. Large quantities of it are constantly forming at the bottom of this pond, and it requires to be removed, from time to time, in order to prevent the pond from being filled by its rapid accumulation.

Another extensive deposit of calcareous sinter is found on the limestone slope at Dingman's Ferry, a little above the

Delaware River. It covers an extensive area, and is from fifteen to twenty-five feet in thickness, as may be seen by examining either side of a small stream passing through it, and from which the calcareous matter has been deposited. On the surface, where it is exposed directly to the atmosphere, it is very hard, and emits a ringing sound when struck with the hammer. A few feet from the surface it is soft and pulverulent, and of a light gray color. It contains numerous beautiful and perfect impressions of leaves, branches, etc.

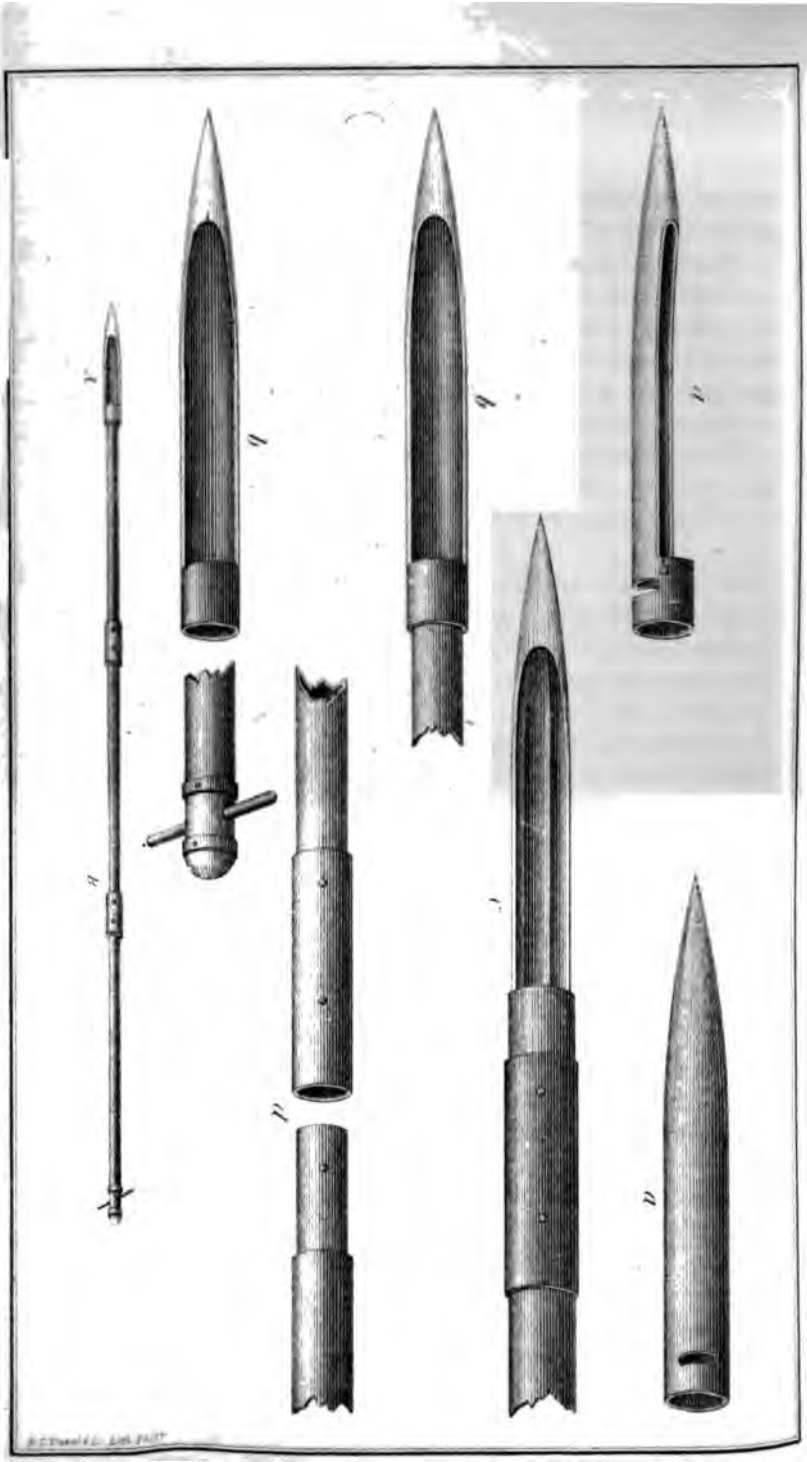
Inexhaustible quantities of marl and calcareous sinter may be obtained from the above localities at a comparatively trifling expense.*

In the Kittatinny and Wallkill Valleys, deposits of marl are numerous. They are found several feet in thickness, at the bottom of the lakes and ponds, marshes, and meadow lands so abundant in these districts. A very common name for these small collections of water is "White Pond," of which several are so called in the county. This name is given to them on account of the deposits of shells distinctly visible at their bottom.

Peat and marl are found in abundance in Vernon Township, on Black Creek, the meadows opposite the town of Vernon covering an area of several hundreds of acres. The peat here varies from four to fifteen feet in thickness, and the marl from one to ten. Numerous other localities have been noticed and will be referred to in a future report.

Deposits of marl occur most generally in peaty meadows and marshes; and in such places may be easily examined by thrusting through the surface a pole or rod, to which the marl, if present, will adhere. It may also be done by means of a spade or shovel; but the examination is sometimes tedious, on account of the presence of water, which often removes the marl from the pole, or renders the use of the spade laborious. An instrument admirably adapted to such examinations has been employed during the past year. It is so con-

* For analyses of specimens from each, see the annexed Report of Mr. Wurtz.



structed that a quantity of peat, marl, soil, etc., may be taken from any depth without mixing it with the other materials surrounding it.

The accompanying figures will give an idea of its construction: A B is the whole instrument, sixteen feet in length. A is its point or borer; B its handle. The point or borer, A, is twelve inches in length, and one inch and a half at its greatest diameter. It is formed of two half cylinders, an exterior, *a*, and an interior, *b*. They are so arranged that when put together, as at *c*, the exterior rolls upon the interior, causing the whole to present the form of a conical or tapering cylinder. The handle is made of strong wood, and in detached portions, four feet in length, which may be connected at pleasure, by means of an iron band, as at *d*. The object in having the handle in detached portions is for convenience of transportation, and for increasing its length as circumstances may demand. The instrument being closed, as represented at A B, it is forced into the peat or marl to the depth at which the examination is to be made; then by turning the handle to the right, the pressure on the exterior cylinder, forces it behind the interior, and in this manner the instrument is opened. It is then forced downward six or eight inches, or the length of the cylinder, when the hollow becomes filled. The handle being then turned towards the left, the cylinder encloses a portion of peat or other matter taken from the spot where the instrument stopped. Its precise depth is indicated by the number of feet and inches represented on the handle.*

USE OF SHELL MARL AS A MANURE.

In Europe, as well as in some parts of this country, shell marl has long been considered one of the most valuable of fertilizers. It not only possesses every property of lime in

* For a description of this instrument, from which it was made, I am indebted to Leo Sesquereaux, of Columbus, Ohio, a gentleman who has made extensive examinations of the peat and coal lands of Europe and this country.

its action upon soils, but it very often contains phosphoric acid, ammonia, organic matter, and other substances which increase its value.* Its principal constituent is carbonate of lime, in the form of what is called "mild lime," because free from that causticity which quicklime, slaked by water or air, possesses, and which is very often injurious to soils. Its pulverulent state gives it an advantage over lime, for it simply requires to be removed from the deposits and spread on the land, or composted with muck or peat, or exposed in heaps for a time, as circumstances may demand; while lime, before it can be applied to soils, must be quarried, burned, slaked, &c. It may be advantageously employed in certain forms and quantities, and under proper circumstances, to all soils. The quantity and form in which it should be applied is indicated by the character of the soil. On peaty soils, or those which contain a large amount of vegetable matter, it may be used in great quantities, either by spreading it broad cast, directly after taking it from its bed, or after it has been drawn to some convenient place and suffered to remain in heaps exposed to the air, six or eight months; or even after it has been burned and slaked like limestone. In the latter case it becomes caustic lime, and should be used only upon soils which contain a great quantity of inactive vegetable matter, as is often the case in low peaty lands, or where there is a large deposit of muck. Such lands are abundant in Sussex County. They are chiefly situated in springy places, on streams, etc., as the numerous peat and bog meadows on the Little and Big Flatkill, the drowned lands on the Wallkill, the marshes and swamps on the Paulinskill, Black and Papakating creeks, and, in fact, on all the streams, large and small, in the county. There are thousands of acres of such lands in this part of the State, lying perfectly useless, and in many cases generating malarious diseases, which, on being reclaimed by thorough drainage and a free use of lime, would be deprived of their malarious poisons, and rendered the most productive soils in the State.

* See analysis by Mr. Wurtz in the annexed report.

In the use of lime as a fertilizer, it may be established as a general rule, that it is only to such lands that it should be applied in its caustic state.*

Shell marl, either alone or composted with peat and muck, may be advantageously used in large quantities on clayey, sandy, and loamy soils. The principal object in composting it with peat and muck is, at the same time, to add organic matter to the soil. If the soil contains already a sufficient quantity of organic matter in an active or proper state, it may be applied alone. Its mechanical action on many soils, particularly on hardpan, or clayey soils, rendering them more pulverulent and open, is of great importance. It may be advantageously employed upon poisonous soils. Copperas or sulphate of iron renders land sterile. Whenever a soil is derived from the debris of a rock wherein is found iron pyrites, (sulphuret of iron,) it will contain sulphate of iron, and very often in sufficient quantities to destroy vegetation. An instance of this was observed in Frankford Township, near the County Poor House. In its vicinity was a ridge of slate containing a large amount of pyrites, which, being very soft, is constantly undergoing decomposition, and forming sulphate of iron, and this is carried over the soil and mingled with it by the wash of the ridge.

To a calcareous soil, or one which has been formed from the debris of limestone rock, it may be applied in small quantities alone, or composted with large quantities of vegetable matter. On the northwestern slope of the Blue, or Kittatinny Mountain, the course of the Little Flatkill is near the dividing line between the limestone of the Helderberg Series, and the red sandstone and shales of the Medina Sandstone. The soil on the limestone hills between the Little Flatkill and the Delaware

* By caustic lime, is understood the hydrate of lime, or that form produced by slaking freshly burned or quick lime with water. Its caustic property is greatest directly after being slaked. From that time the carbonic acid of the atmosphere, uniting with it, drives off the water, and taking its place diminishes its caustic property. This action continues until all the water is driven off, and it becomes carbonate of lime, or mild lime.

River is chiefly of a loamy, calcareous nature, formed by the disintegration of the various kinds of limestone and sandstone bowlders which are very abundant over its surface. On the other side of the Little Flatkill, between it and the summit of the mountain, the soil is of a sandy nature and deficient in organic matter. On this soil the shell marl, either alone or composted, would be of great advantage. On the other side of the Kill it should be applied, as a general rule, in smaller quantities, together with vegetable matter. Thus it will be seen that various circumstances, such as the nature and character of the soil, manner and form of application, &c., should guide us in the use of this material as a fertilizer; and when all these things are properly considered, it will undoubtedly prove a cheap and effectual means of enriching the soils of this county. It may be used to a certain extent in place of gypsum, of which there has been a great consumption here. By referring to the analyses of Mr. Wurtz in the annexed report, it will be observed that this material, (sulphate of lime or gypsum,) is sometimes found as one of its constituents. No general rule can be given in regard to the quantity of marl which may be applied per acre. This must depend on the various circumstances to which we have already referred, as well as on the composition of the marl, its per centage of carbonate of lime, &c.

Although this valuable fertilizer is found in such extensive and accessible deposits in every part of the county, it has been but very little used. This is doubtless owing to the injudicious manner in which trials of it have, from time to time, been made. On account of its great accessibility, and through ignorance of its nature, it has been applied in such large quantities as to destroy vegetation and render the soil sterile for a number of years. On the property of Mr. James H. Struble, in Sandiston Township, is a barren spot of land to which marl, or calcareous sinter, was applied eighteen years ago. Since this time, as I was informed, no vegetables would grow except when a heavy coat of barn-yard manure, or vegetable matter, is applied to it, and then but one luxuriant crop can

be obtained. This experiment not only proves the injurious effects of too large a quantity of this material, but it also speaks volumes in its favor. It has been used by Mr. Van Syckle, in this vicinity, and by others in different parts of the country, with great success. These facts, together with the high estimation in which it is held in the State of New York, and wherever it has been extensively and judiciously used, should be sufficient to dispel the prejudice so prevalent among the farmers of this county, that it acts as a poison to vegetation.

I am, Sir,

Your very obedient servant,

WILLIAM KITCHELL.

NEWARK, N. J., *January* 15, 1855.

REPORT

OF PROFESSOR GEORGE H. COOK, ASSISTANT GEOLOGIST.

To Dr. Wm. Kitchell, Superintendent of the Geological Survey of New Jersey:

DEAR SIR:—In pursuance of my duty as Assistant Geologist, charged with the survey of the southern part of the State of New Jersey, I respectfully submit the accompanying Report.

The instructions received were to make a geological survey of the eastern half of Monmouth County, and report upon the same at the close of the present year. In accordance with these, the survey has been prosecuted either in the field or in the laboratory from July twenty-seventh to the present time. It has not yet been brought to a conclusion, but is in such condition that it can be completed at an early day.

At the commencement of a survey of this kind, many of the examinations must be of a general character, and such as have a bearing upon all the work which is to follow. For this reason, while the main part of my examinations have been made in the eastern part of the county, I have made one excursion to its western part, and another entirely across the State, and down to Salem. I trust that the work already done will be found useful, and that the foundation is laid for prosecuting the survey with accuracy and dispatch.

Very respectfully,

Your obedient servant,

GEO. H. COOK.

RUTGERS COLLEGE, *December* 30, 1854.

REPORT.

GENERAL REMARKS.

That part of New Jersey which, in the Geological Survey, is assigned to the southern division, includes all that portion of the State lying south of a line drawn from Staten Island Sound, near Elizabethport, to the Delaware River, a little below Trenton. The line follows the southeastern border of the red shales and sandstones which stretch across the central part of the State. Its general direction is straight, and its bearing a little west of southwest. The extreme length of the district is one hundred and ten miles, and its greatest breadth about seventy-five miles. Its area is estimated at not far from three thousand four hundred square miles.

In its physical geography, it is remarkable for its lack of hills, its sandy soil, its extensive pine woods, and for the almost entire absence of rocks.

The Nevisink Hills are three hundred and ten feet high,* and a chain of hills of a somewhat less elevation extends from them in a westerly direction to Freehold. South of these the country seldom rises more than sixty feet above the level of the sea.

A belt of clayey or loamy soil, several miles in width, extends across the northern border of the district, and down the Delaware River to the bay; and streaks of clayey soil are generally found on one or the other of the banks of the streams

* See Gordon's Gazeteer, p. 1.

running into the Atlantic. With these exceptions the soil is a light sand, and extensive tracts of it are still covered with pines and scrub oaks.

A kind of cemented gravel or pudding-stone, firm enough to be used for the commoner purposes of building, is found in some of the higher hills, and thin layers of limestone, which can be burned into lime, are found in a few places; but solid beds of rock are nowhere met with.

"The whole of the district is tolerably well watered; but the streams are neither large nor rapid, and are remarkable for the depth of their beds, which cause, indeed, almost the only inequalities in its surface." "Most of the streams have crooked courses, and flowing through a flat country, are commonly navigable some miles from their mouths. Unlike the rivers of hilly countries, they are steady in their volumes, and uniform supplies of water can be more confidently relied upon."*

There being but little water power, manufacturing is not carried on to any considerable extent. Deposits of bog iron ore are found, and a small amount of iron is made from them; and there is an abundance of excellent sand for glass making, which, with the cheapness of fuel, has caused the establishment of numerous glass-houses. The principal business of the inhabitants is agriculture. In this, remarkable advances have been made within a few years. In 1834, Gordon says, "An immense forest covers probably four fifths of this district, and forty years ago it was not worth more than from six to ten cents an acre. From this they have risen to an average price of six dollars an acre."

The following statement, compiled mostly from the United States Census of 1850, shows nearly its present condition.

* See Gordon's Gazetteer.

COUNTIES.	FARMS IN ACRES.		Average value per acre.
	Improved.	Unimproved.	
Third of Mercer,	31.793	7,196	$54 13
Half of Middlesex,	57.969	21,053	41 21
Monmouth,	145.739	82.440	50 46
Ocean,	26,466	28.387	19 86
Burlington,	132 017	40,670	67 56
Camden,	53 968	77,416	35 40
Atlantic,	15.006	34,585	13 80
Gloucester,	68.810	52,897	37 37
Salem,	105.956	38,942	45 88
Cumberland,	48 469	71.646	22 10
Cape May,	14 310	37,653	15 87
Total,	700,503	492,885	Mean 41 70

The following table, compiled from the same sources, will furnish data for comparison with the whole State, and also with the neighboring States.

STATES.	Area in acres.	FARMS IN ACRES.		Average value of farms per acre.
		Improved.	Unimproved.	
Massachusetts,	4,640,000	2,133,436	1,222,576	$32 50
Connecticut,	3,040,000	1,768,178	615,701	30 50
New York,	29.440,000	12.408,968	6,710,120	29 00
New Jersey,	4,384,640	1,768.991	984,955	43 67
Pennsylvania,	30,080,000	8,628.619	6,294,728	27 33
Delaware,	1,356,800	580,862	375,282	19 75
Maryland,	7,040,000	2,797,905	1,836,445	18 81

In these tables the improved lands include only such as produced crops; the unimproved, such as did not produce crops, but were connected with the farms. Unoccupied land is not included under either of these heads.

A comparison of the first and second table shows, that while the value of the land in farms is a little less in the southern division than the average of the whole State, it is still greater than that of any other State mentioned, and it is greater than that of any other State in the Union. I have not

been able to ascertain the areas of the counties separately, and cannot give the amount of land in farms, compared with that still unoccupied. But if we suppose one half of the State to be in the southern division, a little more than one half its area must be in farms, which is less than in Massachusetts, Connecticut, New York, and the northern half of New Jersey; and greater than in Pennsylvania, Delaware, and Maryland.

The climate is mild or even warm, and the early springs and light soils enable the farmers to furnish the first supplies of garden produce to the markets of New York and Philadelphia, and a large part of such supplies for those cities is drawn from New Jersey. Of other crops, Indian corn and potatoes are raised in largest quantities. Wheat, rye, oats, and sweet potatoes are extensively cultivated. The amount of live stock is much above the average of our country.

The rapid advance of agriculture in this district is due in part to its location, in part to the improvement of the country generally, but more is to be ascribed to the use of a kind of marl which is found here in immense quantity. The belt or strip of land under which this is found lies obliquely across the State from Sandy Hook Bay southwest to Salem. Its length is about ninety miles, and its breadth fourteen miles at its eastern extremity, and six miles at its western. Its area is nine hundred square miles, or five hundred and seventy-six thousand acres; and its benefits are shared by a considerable district of country lying on each side of it, so that the whole area improved by it is swelled considerably beyond the above amount. It has been worth millions of dollars to the State in the increased value of the land and produce, besides the influence it has exerted in awakening and fostering a spirit for agricultural improvement. Requiring labor and not money from those who would enjoy its benefits, it has been found admirably adapted to encourage and reward enterprising industry.

The attention of men of science has been frequently called to this interesting formation on account of its value in agricul-

ture, and also for it numerous and remarkable fossils; bones, shells, sharks' teeth, &c., being common in it. Its geological character was first distinctly shown by Professor L. Vanuxem, Dr. Morton, and Mr. Conrad, of Philadelphia, in eighteen hundred and twenty-seven. In eighteen hundred and thirty-five, the legislature ordered a geological survey of the State to be made. This was done by Professor H. D. Rogers, and his final report was presented in eighteen hundred and forty. This report included a very full account of the marl, both geological and chemical. Numbers of analyses of the varieties of it have been made by other chemists; some of these are important, and will be referred to again. Under such circumstances, the present examination was entered upon with a good deal of distrust; and nothing but a knowledge that the openings into the marl were much more numerous and extensive than when Professor Rogers closed his survey, and that thus an opportunity for study was now presented which was not then available, could have induced an attempt to re-examine what had already been so well done.

DESCRIPTIVE GEOLOGY.

From examinations in the field, the following facts are proved:—

1. The clays and marls, which constitute the basis of most of this part of the State, are in regular and continuous layers.

2. These layers are not level, but incline or *dip* towards the southeast. They have been observed to descend from twenty to fifty feet in a mile.

3. Since these layers were formed, the action of water, or other causes, has worn away and changed the surface of the country.

In passing across the country from the north towards the south, we come upon the different layers in orderly succession; in examining the pits which have been opened for marl, the succ.ssive layers are always found in the same order; exami-

sections upon the sides of hills where they have been cut into, show the same order that is found in the lower grounds to the south of them; and the same fact is observed in the banks of streams which cut through the layers.

From the fossils found in these beds, geologists have determined that the marls and the clays north of them, and between them and the red sandstone, belong to the cretaceous or chalk formation,* and that the beds on the southern border of the marl belong to the tertiary. The sands and some of the clays south of these, are probably of more recent origin.

The general principles stated above, are all exemplified in Eastern Monmouth; the clays are found on its north side, the marls across the centre, and the sands on the southern side.

I. The clays occupy the county between the northwest line of the county and the northern sides of the hills which extend from the Nevisink to Mount Pleasant, and on to near English-town. On the shores of Sandy Hook and Raritan Bay, the clay is thickly covered with sand. In the valleys between some of the hills mentioned, it extends considerably further south. It is almost black when wet, but is gray when dry. It contains a good deal of micaceous sand. The trunks and branches of trees, in the form of lignite, are found in it in great quantities, and frequently associated with sulphuret and sulphate of iron. Irregular streaks of green marl are also found in it; in some places enough to make it valuable as a manure. Characteristic fossils are also found. The examinations made thus far have not been sufficient to furnish precise descriptions of the position or qualities of the different layers or even of the beds of this stratum.

II. The marls are found in various parts of the country from the south line of the clays to a line drawn from the At-

* A "formation," in geology, is "that collection or assemblage of beds or layers, strata or portions of earth or minerals, which seem to have been formed at the same epoch, and to have the same general characters of composition and lodgement." (Webster.) In this report I will use the terms stratum, bed, and layer, for the successive subdivisions; thus dividing the formation into "strata," each stratum into "beds," and each bed into "layers."

lantic shore, near Great Pond, in Deal, to the Manasquan River, between Upper and Lower Squankum.

The substance here called marl, is not the ordinary calcareous clay or earth, which is distinguished by its light color and its effervescence with acids, but is a kind of earth, most of which is in little rounded grains, about the size of fine gunpowder; its color is usually some shade of green; the crushed grains are always green; and they are so soft that they can easily be crushed on the nail; they scarcely effervesce with acids. Besides the grains in the marl, there is generally a little white sand and some clay; the latter being of various shades of black, brown, drab, or green, and so mixed in as to give color to the whole; great numbers of shells are found in some of the layers; these of course cause the marl to effervesce. The marl grains are known in geology as *greensand.*

Though the whole series of beds which is exposed in the district now under examination, is called the *marl stratum*, yet marl grains are not found in all the beds, some of them consisting entirely of sand, and others of clay.

There are three distinct beds of marl in the stratum: the *first* includes those found north of the north branch of Shrewsbury River, Swimming River, and Yellow Brook; also those found on the head waters of South River, north of Freehold. A few pits have also been opened below tide level at Red Bank. The *second* includes those near the head of the south branch of Shrewsbury River; those near Eatontown; those along the valley of Hockhockson Brook, above Tinton Falls; those a little south of Colt's Neck Village; those about a mile and a half south of Freehold, and those south of Blue Ball; it also includes the yellow marls south of Eatontown and about Long Branch; the same bed is also found near the tops of the hills south of Red Bank and that south of the Phalanx Dwellings, and I think in some of the highest points of the Nevisiak Hills. The *third* bed includes the marls of Deal, Poplar, Shark River, and Squankum.

The bed of yellow ferruginous sand which is so conspicuous a feature in the soil of the Nevisinks, at Red Bank, at

Gulf's Neck, and indeed entirely across the State, lies between the first and second beds of marl.

A bed much resembling beach sand, with a very few marl grains scattered through it, lies between the second and third marl beds.

The several beds of marl are each made up of distinct layers, which vary in appearance and in properties.

In the first bed five distinct layers may be recognised.

1. A layer of sand and fine gravel, from two to four or more feet in thickness. This is very distinctly separated from the clay which lies immediately under it. It contains numerous fossils, a considerable proportion of marl grains, and is valuable as a manure. It is known as *sand marl*.

2. A layer of nearly pure marl grains, of variable thickness, averaging perhaps four feet. A little blackish clay is mixed with the marl, from which it is generally known as *black marl*. It contains but few fossils. As a manure it is highly prized. Though always found, it is not very distinctly separated from the next layer.

3. A layer of from twelve to sixteen feet in thickness, known as *blue* or *gray* marl, from its containing a considerable amount of a drab colored clay, inclining to bluish or grayish. It has numbers of very large and heavy oyster shells in it—generally there is a streak from eight inches to two feet thick, which is almost solid with shells. This layer is very highly prized as a quick and lasting fertilizer. It changes gradually into the one next above.

4. Three or four feet of *black marl*, almost exactly like that of No. 2. It is not found distinctly marked in all places.

5. Dark colored marl six or eight feet thick, containing fewer and fewer of the marl grains in its higher parts, and at last only to be distinguished from the dark clay into which it runs, by the thin flaky shells scattered through it.

The thickness of this bed of marl is at least thirty feet. The whole can be seen in the side of the Nevisink Hills on the shore of Sandy Hook Bay. They have all been passed through in the pits of the North American Phalanx, and Mr.

William Hartshorne had them bored through for me in his pits, north of Freehold. All except the top layer is well exposed in the pits of Wm. Conover, near Marlboro'. And they can be seen in succession, by passing along the valleys of any of the streams which run through the marl, as the Spottswood north and south branches of South River, and in the Hop Brook from Taylor's Mill to Marlboro'.

The following circumstances may produce a little difficulty, at first, in verifying the preceding statements. Whenever the clay, which lies immediately over this bed of marl, has been worn away, and the marl lies above the bed of neighboring streams, the rains and surface water penetrate it, to a greater or less depth, and leach off; dissolving out the fossils and leaving earth in their places; changing its color to a rusty red; and forming numerous flaky crusts, or sometimes strong cakes of impure oxide of iron, in it. Such marls are called *dry bank* or *hill* marls. These changes have taken place to a much greater extent in some localities than in others. Marls which lie so as not to be subject to the action of surface water, or drainage, are called *wet bank* or *meadow* marls.

The characteristic fossils of this bed are Exogyra costata, Gryphaea convexa, Ostrea falcata, Terebratula sayii and Belemnites americanus. A great many others are found, but they are not so numerous and not so generally present in all localities.

Lying immediately upon the bed of marl which has just been described, and not separated from it by any well marked division, is a layer of black clay. It contains scales of mica and grains of sand. In small quantities it cannot easily be distinguished from the clay of the stratum below the marl. It frequently contains sulphate of iron (copperas); and being often mistaken for marl has been used to the injury of the farmer. When composted with quicklime it is thought to be useful. It is from ten to twenty feet thick.

The red or ferruginous sand lies upon the clay just mentioned. It is separated from it by a well marked line of division. This bed is of great thickness; not less than one

hundred feet at Red Bank, and in the Nevisinks it is equally thick. Whenever this sand has any degree of firmness it is full of the impressions and casts of shells and other fossils. The lower part of this bed is a very friable sand; towards its upper part a greenish clay is found mixed with the sand, giving to it a good degree of firmness; the rock at Tinton Falls is an example of this. The upper part of this bed, from four to six feet, is a layer of greenish indurated clay, in some places hard enough to be called a rock. It slakes on exposure to the weather. No marl grains are found in it; but it is called marl by many farmers, and is profitably used as such.

The *second bed* of marl is not so extensively developed in this part of the country as the first one; though it is considerably thicker. Its several layers may be described as follows:—

1. A layer of marl containing but very few fossils; its lower part almost clean grains; clay is mixed with the grains in the upper part, in many localities. The color of the grains in this layer, and indeed in the whole bed, is green with a shade of yellow, unlike those in the first bed, in which the color is green, with a shade of black or dark blue. I have not in any place in this part of the county found the layer worked more than fourteen feet, though I believe it to be much thicker. In the pits of Mr. Imlay, on Crosswicks Creek, a short distance below New Egypt, it is nearly twenty-five feet.

2. A layer of from ten to fourteen feet of marl, with numerous shells. A streak in the upper part of this, for two or three feet, is almost solid with shells of the Terebratula harlani; and another layer near the bottom of it is equally solid with shells of the Gryphaea convexa. This layer gradually loses its marl grains, at the upper part, and runs into

3. A layer of broken shells with more or less sand intermixed, and containing scarcely any marl grains. The color of this marl is *yellow* or *gray*. In the neighborhood of Eatontown it is called *yellow marl*. No localities have been visited in Eastern Monmouth where it has been penetrated more than fourteen feet, but near Salem it has been opened for more than twenty feet.

There are no good localities where all these layers are to be seen together. The nearest approach to it is in the pits of Mr. Strickland, near Blue Ball, where the top of the first, the whole of the second, and the bottom of the third layers are shown. The meeting of this bed and the clay of the sand bed under it is well shown in the marl pits of J. S. Trafford, Daniel Polhemus, and John S. Cooke, above Tinton Falls. Also in the pits of Mr. Lafetra and Mr. Lippincott, on the north side of Parker's Creek, near Eatontown. The *yellow marl* is dug near the Turtle Mill at Long Branch. Also by Dr. Lewis and others, of Eatontown. The bottom of Edward Wolcott's marl, near the latter place, cannot be distinguished from the top of Strickland's.

A large number of species of fossils are found in these different layers. Those mentioned under (2) are the most common and characteristic. The Gryphaea convexa of this bed is much smaller and thinner than that found in the first.

The bed of sand between the second and third beds of marl has nothing remarkable about it, except the grains of marl scattered through it. Its meeting with the top of the second bed is not known to have been found. It can be seen under the third bed in the pit of Elisha West, of Deal, that of Rulief Vandeveer, of Poplar, that of Thomas Longstreet, of Squankum, and it is said under that of John Shafto, of Shark River. The bed itself has been opened near Elisha West's, in Deal, and the sand used as a fertilizer on account of the marl grains in it. It bears a striking resemblance to the beach sand of the neighborhood which has also been used for the same purpose. No opportunity has occurred for measuring the thickness of this bed, but from the inclination of the beds above and below, it may be estimated at not less than thirty feet.

The *third bed* of marl may be described as consisting of three layers, as follows:—

1. Twenty feet of green marl. This contains a considerable percentage of greenish clay: it is distinguished as a quick and powerful fertilizer; the most noted marls of Squankum, Shark River, Poplar, and Deal are from this layer.

2. Fifteen or twenty feet of a pale greenish clay or earth. No marl grains are found in this layer, though it is called marl and possesses active properties as a manure. It is flaky in its structure, and when exposed to the air fades to a light ash color.

3. From five to fifteen feet of the above clay, largely mixed with marl grains.

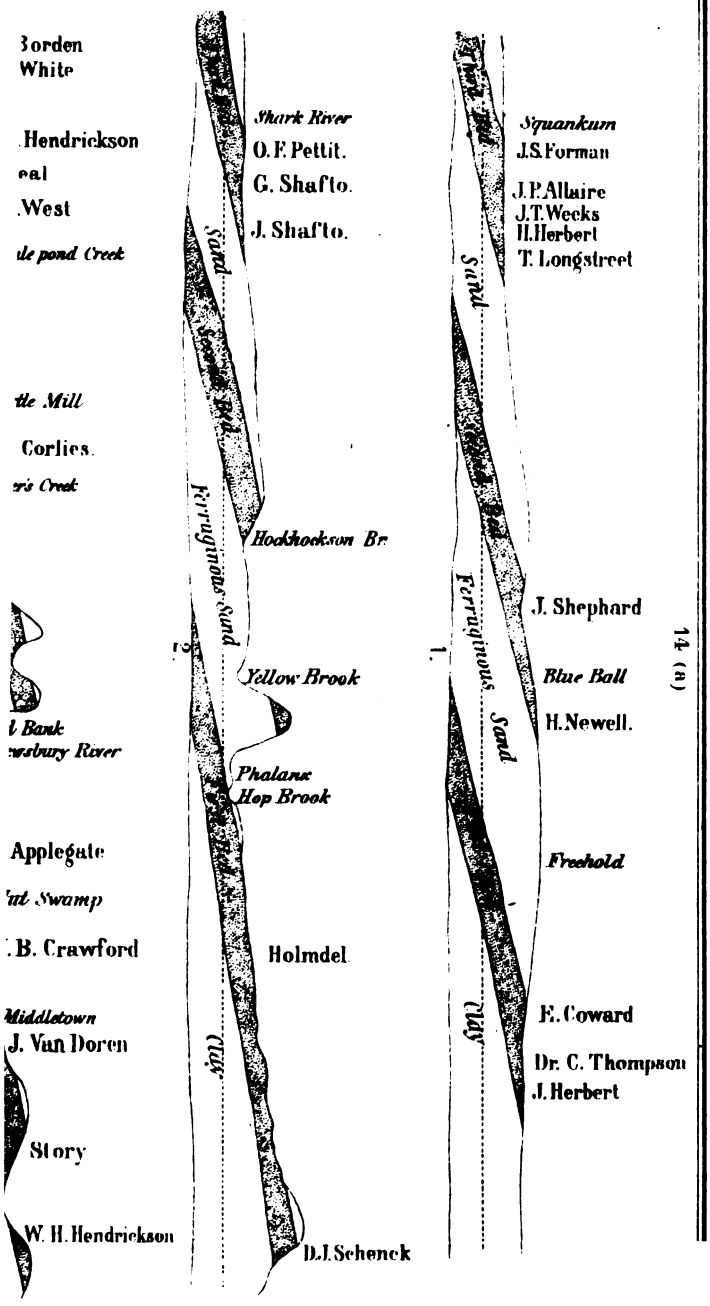
The last named layer is opened to the greatest thickness in the pits of Jacob White, Peter Drummond and Amos White, in Deal; in that of O. F. Pettit, Shark River, and in that of J. S. Forman, near Lower Squankum, it is not so thick. In all these it can be seen running into the layer next below.

There are no localities where all these layers can be seen in a single place, but they can be seen in succession in numbers of places, as in the pits of Elisha West, G. Hendrickson and Thomas Borden, of Deal; in those of J. Shafto, H. Hurley, G. Shafto, and J. L. Tilton, of Shark River, and in those of T. Longstreet, T. Weeks, and J. S. Forman, of Squankum.

Fossils are not very abundant in this bed. A few casts, and still more rarely shells, have been found in the lower layer; it is not known that any have been found in the middle layer; in the upper, casts and impressions of shells are found. They have not been examined with sufficient care to determine the species; they are, however, entirely different from those of the two lower beds.

The accompanying sections across the marl stratum, show the positions of the several beds. The scale of distances is two miles to one inch. The scale of heights about 400 feet to an inch: the heights, however, have not been accurately measured. These sections are taken at right angles to the stratum.

In addition to showing the positions of the several beds, they also exhibit the effects of peculiar configurations of surface on the extent of the marl bed exposed: thus though the same beds are shown in each of the three sections, the amount of marl at the surface appears to be quite different in the same bed as seen in the different sectional views. The first bed ap-


Borden
White
Hendrickson
eal
West
le pond Creek
tle Mill
Corlies
ris Creek
l Bank
wsbury River
Applegate
ut Swamp
B. Crawford
Middletown
J. Van Doren
Story
W. H. Hendrickson
Shark River
O. F. Pettit.
G. Shafto.
J. Shafto.
Sand
Ferruginous Sand
Hockhockson Br
Yellow Brook
Phalanx
Hop Brook
Holmdel
Clay
D. J. Schenck
Squankum
J. S. Forman
J. P. Allaire
J. T. Weeks
H. Herbert
T. Longstreet
Sand
Ferruginous Sand
J. Shephard
Blue Ball
H. Newell.
Freehold
Clay
E. Coward
Dr. C. Thompson
J. Herbert
14 (8)

pears three or four times as extensive in the second and third sections as in the first.

III. The sands which form a strip along the southern border of this county join the marls in a very irregular line, ridges of them extending up almost to the middle of the county, while in the valleys of the streams, the marl comes to the surface several miles further south. They have not yet been examined with sufficient care to render it necessary to make any report upon them.

The interest felt in the marl stratum by a very large portion of the inhabitants of Monmouth, has induced me to devote most of the time, thus far, to ascertaining and systematizing facts relating to it. The examinations of the clay stratum and of the sands promise to be of much practical utility, though the soils where they occur have not yet been brought to the high state of cultivation of the marl region, and they are generally thought of less value.

The regular order of occurrence of the different beds of marl in the district surveyed led to a desire to examine their relative position in the southwestern part of the State. For this purpose the stratum was crossed from Allentown to New Egypt, and again in the vicinity of Salem, and the same order of succession of beds was found.

The marl pits of N. Woodward, at Cream Ridge, belong to the first bed. The ridge itself is part of the ferruginous sand bed. The pits at Hornerstown, and those of Mr. Imlay and Mr. Horner, near New Egypt, are in the second bed; so also are the gray marls, such as those in Governor Fort's pit. The pits of Mr. Irons, south of New Egypt, and others from there on to Poke Hill, in Burlington County, belong to the lowest layer of the third bed. The upper layers have not been found in that vicinity.

The marls in Salem County, at Mannington Hill and at Woodstown, belong to the second bed. At Batten's Mill, above Swedesboro', the first marl bed is seen. The ferruginous sand lies between the two. The third bed has not, to my

knowledge, been found in Salem County. The marl at Mullica Hill belongs to the second bed. William H. Snowden, of that village, showed me a collection of tertiary shells from a locality about two miles south or southeast from there, and among these were some casts of shells of the same species with those found in the lower layer of the third bed. I hear that he has since found the bed containing those characteristic fossils.

From the report of Professor J. C. Booth on the Geology of Delaware, it appears that at least two of these beds are found in that State. The stratum is known to extend into the States farther south.

The hasty examination given to the different beds west of Freehold, does not enable me to decide whether they retain the same thickness, or whether the first and third beds grow thinner towards the southwest. They are not as well exposed or as extensively worked; the greater portion of all that is used, being taken from the second bed. Other causes than the thickness, however, affect the amount of their exposure. For example, the increased breadth of the marl stratum on the eastern side of the State is partly due to its northern border being on elevated ground and its dip towards the southeast only a little more than the slope of the country in that direction; while on the western side of the State, the stratum is diminished in width from its northern border being on low ground and its dip to the southeast, contrary to the surface of the country, which rises in that direction. The several beds are much better exposed in a rolling country than in one that is even or flat; thus, in the district surveyed, the first bed, though thinner than either of the others, is by far more exposed than both of them together. The country in which it occurs is uneven and hilly; the marl may then be found either in the valleys or the side hills, and these are so common that almost every farm has a marl pit on it, and in some a pit is opened in every field. The country is much more even and level where the second and third beds are found, the valleys of the streams making almost the only inequalities of the surface,

and it is in these principally that the marls are dug. The practice in this respect is so uniform that many persons suppose they are only to be found in the valleys of streams. A knowledge of the fact that the beds are to be found on high as well as on low ground, that they continue nearly uniform in quality and thickness in straight lines across the State, and that they descend towards the southeast with a very regular slope, will, it is hoped, lead to a more general opening of pits in neighborhoods where marl is not now known to exist. Marls have been carted long distances, and deposited on lands which were underlaid by marl, and such, from my own observation, I am satisfied is still being done in many places. In addition to the advantages to the farmer from having an abundant supply of marl close at hand, the value of good marl pits should be taken into the account. Pits ten feet square, and as deep as the purchaser chooses to dig them, are sold for from five to seven dollars. An acre contains forty-three thousand five hundred and sixty square feet, or more than four hundred and thirty-five such pits, worth, at the lower price, two thousand one hundred and seventy-five dollars, and at the higher price, three thousand and forty-five dollars. Such lands are worth searching for, and, if the work is judiciously done, they will be found. The following directions may aid in making examinations.*

Knowing that the general direction of the beds is a little west of southwest, a line traced in that direction from any pit already opened, will continue on the same bed. Or a line run between two pits of the same bed, will continue on the same throughout. Searches by digging down or by boring may be

* Borings for marl can be easily made with a common auger; an inch and a half one is large enough. Its shank may be lengthened as much as is required by welding on a rod. The handle should be made to slide on this rod, and fasten with a set-screw or wedge. The auger needs raising every few inches to clear it, and to examine the material penetrated, some of which will be found sticking in the twist of the instrument. With such an auger, a hole from ten to twenty feet deep can be made in a few minutes.

made anywhere on such lines; the lowest ground will usually have the least thickness of soil or *top dirt*. If this dirt is found too thick for profitable working, other places may be tried, for the marl is worn or gullied in its upper surface sometimes, and the best points for opening may not be hit at the first trial. If the lines are run over uneven ground, allowance must be made for the dip or descent of the beds, which is towards the southeast, and at the rate of from twenty to fifty feet a mile. This dip will cause beds to appear further to the northwest if the ground is higher, and to the southeast if it is lower than that started from.

COMPOSITION OF THE MARL, AND THE CAUSE OF ITS FERTILIZING ACTION.

The value of this deposit as a manure, and the surprising influence it has upon the agriculture of a large district of country, have drawn the attention of scientific farmers and chemists to its composition.

Mr. Seybert, of Philadelphia, made a careful analysis of this marl, which was published in 1822, in the second edition of Cleaveland's Mineralogy. He found ten per cent. of potash in it.

James Pierce, Esq., examined the marl beds of New Jersey, and published an interesting account of them in Silliman's Journal, Volume VI., page 237, in 1823. He attributes the virtue of marl principally to its shells and other calcareous ingredients.

Dr. R. Harlan, in a paper containing remarks on the Geology of West Jersey, in Volume IV., page 15, of the Transactions of the Academy of Natural Sciences of Philadelphia, in 1824, attributed its value in some cases to its fossil shells, in others to the iron pyrites in it, and in still others to the clay which it contained.

A paper on the same subject, Volume VI., page 59, Trans-

actions of the same Society, in 1828, by Professor Lardner Vanuxem, says, "the marl of New Jersey and Delaware appears to owe its fertilizing property to a small quantity of iron pyrites (which passes to sulphate of iron by exposure to the air), and also to animal matter, to its color, and to its effect when mixed with sand, of diminishing the calorific conducting power of the latter."

Prof. Rogers, in his Geological Report of New Jersey, considers that there is abundant evidence "to prove that the true fertilizing principle in marl is *not lime* but *potash*."

Prof. J. F. W. Johnston, in his Notes on North America, made in 1850, Volume II., page 308, says, that on analyzing some of the green grains and sand, he found "from one to one and a half per cent. of phosphate of lime," and to this he attributes its fertilizing power.

In the Working Farmer for April 1, 1853, are several analyses of marl by Dr. Charles Enderlin, of New York. His specimens were from the pits of the North American Phalanx. He found two and a half per cent. of phosphate of lime in one specimen. He also found that the alkali was not all potash, but part soda. The fact of soda being a constituent of the marl was published in Silliman's Journal, second series, Volume IX., page 83, for 1850, from an analysis by William Fisher.

Numerous other references might be given, but the above are enough to show that the question is still an interesting one.

The following analyses show the principal constituents. Sulphates of iron, lime and alumina, phosphates of iron and lime, chloride of sodium, organic matter, &c., which can be detected in it in small quantities, will not materially affect the proportions of the principal substances.

The first (1) is the analysis made by Mr. Seybert, the second (2) is the average given by Professor Rogers, and the third (3) is the analysis made by Mr. Fisher.

	(1)	(2)	(3)
Silex,	49.83	48.50	53.26
Alumina,	6.00	7.30	3.85
Protoxid of iron,	21.53	22.80	24.15
Potash,	10.12	11.50	5.36
Soda,			1.60
Lime,		.50 or less.	1.73
Magnesia,	1.83	trace.	1.10
Water,	9.80	7.90	10.12
Loss,	.89		
	100.00	99.50	101.17

The preceding statements and analytical results show that the subject is by no means a plain one. To me it is one of deep interest, and I have taken every pains to inform myself upon the practical agriculture of the district, and the influence which marl has exerted in bringing it to its present high condition. With this knowledge my chemical examinations have been conducted, but they are not yet in such a state of forwardness as to be presented complete. A few approximate results will be given.

In the following table the amounts of phosphoric acid and lime are given, in the first and second columns. They are averages from several analyses of specimens from different pits. The third and fourth columns give the amount of phosphate and carbonate of lime. The phosphate is calculated from the phosphoric acid, and it probably exists in the marl in this form. The only doubt of it arises from the fact that phosphate of iron is a common mineral in this stratum. Careful examinations have not been made to determine the amounts of potash and soda; enough, however, has been done to show that they are always present, and constituting from five to ten per cent. of the whole.

Percentage of Phosphoric Acid, Lime, Phosphate of Lime, and Carbonate of Lime, in marls from the different layers.

BED.	LAYER.	Phos. Acid.	Lime.	Phos. Lime.	Carb. Lime.
1.	1. Sand marl,	0.76	1.00	1.55	0.37
	2. Black marl,	0.63	1.50	1.29	1.50
	3. Blue or gray marl,	1.14	8.50	2.33	13.04
	4. Top marl,	0.00	7.23	0.00	12.91
Fer. Sand	Green clay,	1.20	1.65	2.25	0.71
2.	1. Grain marl,	0.76	0.90	1.55	0.19
	2. Green marl and shells,		10.20		18.21
	3. Shells, yellow marl,	0.00	27.44	0.00	49.00
3.	1. Green marl,	2.80	2.40	5.71	0.00
	2. White marl,	0.78	1.50	1.59	1.23
	3. Blue marl,	1.04	1.70	2.13	1.09
	Dry-Bank marl.	1.14	0.30		0.00
	" "	1.39	0.50		0.00

The results presented agree, generally, with the experience of farmers. The marl containing the largest amount of phosphate of lime, is the first layer of the third bed; the green marl of Squankum, Deal, Shark River and Poplar. It is noted for quick and powerful action when applied in light dressings; from five to twenty loads on an acre produce good effects, and it is sometimes used in even smaller quantities. No. 3 of the first bed is well known as an excellent marl. From one hundred to two hundred loads are commonly applied to an acre, and such dressings last fifteen or twenty years. It will be observed that this layer contains less phosphate, but much more carbonate of lime than the one just mentioned; and probably this is the cause of its more permanent action. The first layer of the second bed seems, from the analysis, to be much better than practice has found it. The difference may be owing to the coarseness and cleanness of its grains, for when mixed with quicklime and applied to the soil, it produces ex-

cellent effects. The dry-bank marls, it will be observed, are deficient in lime; phosphoric acid is found in them in the usual amount. These specimens were from the first bed, and probably the third layer. They have usually been thought equal to the wet-bank marls of the same bed, for a short time, but to wear out sooner. Other comparisons will suggest themselves to the minds of inquiring farmers.

"POISON" OR "BURNING" MARLS.

Marls are found in all parts of the stratum, which are said to be *burning* or *poison* in their properties; so much so as to destroy vegetation. In some cases where they have been freely applied to the soil, they have destroyed its fertility for years. These marls are not confined to any particular layer or bed, but are found in spots or patches in all of them. The dark clays above and below the first marl bed also possess the same properties, and being frequently mistaken for genuine marls, have done serious injury to crops upon which they have been applied. The same is true of the brownish clay, called *rotten stone*, which is found on top of any of the layers of the third bed. In all these cases the injurious effect is due to sulphate of iron (*copperas*), or to that substance mixed with sulphate of alumina (a kind of *alum*). The latter substance is not near as common as the former. Either of them can be easily distinguished by the taste; the copperas is well known by its astringent, inky taste; the other by the taste of alum. When marls, or earths containing them, are exposed to the air, yellowish white incrustations of these salts form on their surfaces. If other tests are desired, take some of the marl and boil it in two or three times its weight of water, in a clean earthen or porcelain dish; then strain the water clear from the marl. The copperas and alum will be in solution in the water. If some of this water is poured into strong tea, it will turn it black; if poured into lime water it turns it a dirty white; and if added to the blue liquid made by pouring hot water on

leaves of red cabbage, the color is changed to a red. If aqua ammonia (*hartshorn*) is poured into it, there is a reddish or greenish sediment formed.

Professor Rogers, in his report, recommended that such marls be exposed to the weather some time before using, that the copperas and alum might leach out. As a still better method, he recommended composting them with quicklime, using perhaps a bushel of lime to a hundred bushels of marl. Wherever this remedy has been tried it has been found effectual, and upon soils which have been injured by the application of such marls it has restored their fertility. It is not so generally practised as it ought to be, most farmers thinking it cheaper to get marl from beds not contaminated with these substances. The action of the lime upon the copperas produces *plaster*, but this is already in the marl, as is shown by its forming a white crust or powder on the surface of marls which are exposed to the open air, as well as by the sparkling little crystals of it which may be seen in many cases. Plaster is not generally found to produce any effect upon soils which are well marled. Still the use of lime with those marls cannot be too strongly recommended, the very fact that copperas and alum are present proving a want of lime, and whenever there is a sufficient amount of quicklime, or of carbonate of lime, in a marl, these substances cannot exist. The use of lime too may give activity to marls, which by themselves are almost valueless, causing the grains to crumble and give up their fertilizing constituents to the growing crops.

Wells which are sunk in the marls frequently contain so much of the copperas and alum in their waters, as to be unfit for making tea or coffee, turning the tea black. A little saleratus or pearlash, or even woodashes, boiled in the tea-kettle with the water, corrects this.

As directed, specimens have been taken from all the layers which have been examined, and from those of the marl, great numbers from different pits in the same bed. The collection of fossils is not as complete as is desirable—such an one requiring more time than it has been possible to devote to it.

A large number has been collected, however, and for many more the survey is indebted to the generosity of friends. Valuable and interesting specimens of fossil bones, teeth, shells, &c., have been received from Capt. T. Weeks of Squankum, Mr. W. Lippincott of Shrewsbury, Mr. J. S. Cooke and Mr. Polhemus of Tinton Falls, Mr. C. T. Matthews of Colt's Neck, Mr. Azariah Conover of Middletown, Rev. Mr. Riley and Mr. H. G. Cooke of Holmdel, and Mr. W. Hartshorne of Freehold. Some remarkably fine specimens of crystallized phosphate of iron were presented by Mr. P. Lafetra of Shrewsbury. The greatest liberality has been shown in regard to specimens, and the collection by donation would have been much larger, had care been previously taken to preserve them. It is hoped that the donations will be much greater the coming season, when it becomes known that as large a collection as possible is desirable to illustrate the geology of the State. Important service can, in this respect, be rendered to the survey.

In studying out the position and peculiarities of the various beds of marl, great assistance has been received from gentlemen residing in the county. All have willingly furnished any information required. Especial notice is due to Mr. W. H. Hendrickson and Mr. G. C. Murray of Middletown, Rev. G. C. Schenck of Marlboro', Mr. C. Sears of the Phalanx, Mr. J. S. Cooke of Tinton Falls, Rev. Mr. Finch of Shrewsbury, and Mr. W. Hartshorne of Freehold. Also, to Hon. W. W. Newell of Allentown, and Ex-Governor Fort and Mr. Thomas B. Jobs of New Egypt, Ocean County, and to Messrs. David and J. J. Pettit of Mannington, and Dr. D. M. Davis of Woodstown, Salem County.

GEORGE H. COOK.

REPORT

OF HENRY WURTZ, CHEMIST AND MINERALOGIST.

NEW JERSEY STATE LABORATORY,
Trenton, January 1st, 1855.

Dr. William Kitchell, State Geologist:

SIR:—On entering upon the duties of my appointment on e first day of November last, my first care was to select a itable place for a laboratory, in which to perform the an- ytical and other work required of me by my instructions. ıch a place having been procured, it was necessary to devote ore than half of the very limited time set apart for the ork of this season to the furnishing and fitting up of such boratory, procuring the requisite apparatus, and prepar- g the reagents and other materials required, in that state of rfect purity necessary to the performance of reliable ana- ses; so that when I found myself prepared to commence ork, from three to four weeks only of the specified period mained, a time altogether too short for the performance of y extended chemical investigation.

Operations were commenced, however, all at once, upon : of the specimens collected by you, comprising four varie- s of calcareous marls and two of calcareous sinters, and hough it has been found impossible to bring these analyses ite to a final close, yet by dint of constant application, an ıount of labor has been accomplished which could scarcely ve been expected, not less than fifty-five quantitative deter-

minations having been made, besides the large amount of qualitative investigation necessary; and the results already obtained possess several wholly unexpected and important points of interest, which hold out high promise of the value of more extended and thorough explorations and investigations of these abundant calciferous deposits.

My results, thus far obtained, are as follows:

I. A.

Marl, taken from the surface of a deposit found upon the estate of Isaac Bonnell, in Montague Township, Sussex County.

It presents the appearance of a light gray pulverulent mass, principally made up of the *debris* of small fresh-water shells, and is mixed with radicles of grass or other roots, and a few small black specks of peaty matter. When heated upon a sheet of platinum, it blackens, smokes with a peaty odor, and burns easily to a nearly white ash, which exhibits a curious kind of repulsion for the platinum while hot, passing into a sort of spheroidal state, and floating in the air, remaining in this condition for a long time, certainly after the expulsion of all volatile matter, and at a temperature too low to cause evolution of carbonic acid, thus indicating the development of a true repulsive force. After cooling, it is found caked together into a compact mass. These phenomena seem to me to be pyroelectric. When heated in a close tube, gives off a considerable quantity of water, which is strongly ammoniacal, together with a tobacco-like odor (indicating the presence of ammonia-crenate of lime).* This ordor is very strong and persistent, filling the whole laboratory with a smell precisely resembling that of an old foul tobacco pipe. At a stronger heat a quantity of tarry matter distilled over. Water boiled for a long time with the marl acquires a faintly yellowish tint, and

* Berzelius, as quoted in Loewig's "Chemie der organization Verbindungen," I. 485.

an odor strongly resembling that of a grist-mill, remaining perfectly neutral in its reaction, and becoming at the same time exceedingly difficult to filter clear. Solutions of the marl in acids possess a light amber color, and little or no smell.

The ingredients of this marl,* with the percentage proportions thus far determined, are—

* Some brief remarks upon the methods used in these analyses will be in place here, although when the analyses shall hereafter be presented in a complete form, minute descriptions of the methods will be given.

The phosphoric acid was detected by the molybdate of ammonia reaction, and the same reaction used, according to the suggestion of Sonnenschein, in its quantitative determination, that is, by precipitating it with molybdate of ammonia, redissolving the washed precipitate in ammonia, precipitating with sulphate of magnesia, and weighing as bibasic phosphate of magnesia. This process seems to present more of the elements of reliability, for determining phosphoric acid when present in small quantities, than any other yet proposed, but it was nevertheless found that the considerable solubility of the yellow molybdic precipitate in the wash-water has a greater influence than has been supposed, and that the determinations made are therefore probably too low. Observations were made, however, which induce the hope of so modifying the method of Sonnenschein, as to eliminate this source of errror, and thus render it as accurate as it is convenient.

Manganese, when present, was detected by Crum's test, with nitric acid and deutoxide of lead, the delicacy and certainty of which cannot be too highly appreciated.

The carbonic acid was determined by means of a small apparatus similar to that described in Rose's Handbuch, last edition, Volume II., page 801.

The amorphous silica by boiling the substance with pure caustic soda solution for a long time in a platinum vessel, evaporating the filtered solution with an excess of chlorohydric acid, collecting the separated silica on a filter, washing, drying, burning, and weighing.

The portion of the marls insoluble in chlorohydric acid was dried upon a weighed filter at 100 deg. C., weighed, and afterwards burnt, and weighed again, the difference between the two weights being, of course, the insoluble organic substances present. The organic acids soluble in chlorohydric acid were determined together with the combined water, by the loss, except in the case of analyses II. B, in which the whole amount of water and organic matter was determined by burning a weighed portion of the marl as perfectly as possible, then restoring the lost carbonic acid by evaporating with carbonate of ammonia, drying and weighing, the difference being, of course, the whole percentage of volatile and combustible ingredients, from which, by deducting the organic matter in the insoluble portion determined as before, was obtained the sum of the organic matter in the soluble portion and the combined water.

The hygroscopic water was determined by drying at 100 deg. C., until the weight was constant.

1. Ingredients soluble in water.

Chloride of calcium, considerable.		
Chloride of sodium, Chloride of magnesium,	traces.	
Organic salts of lime, such as ammonia-crenate, ammonia-apocrenate, and ammonia-humate,	considerable.	

2. Ingredients soluble in chlorohydric acid.

Lime,	50.27	Corresponding to Carbonate of Lime, 89.76.
Magnesia,	0.62	Corresponding to Carbonate of Magnesia, 1.30.
Carbonic acid,	38.57	
Combined water, Organic acids,	by loss. 4.10	
Sesquioxide of iron, with traces of alumina,	0.45	
Phosphate of lime,	0.30	

3. Ingredients insoluble in chlorohydric acid.

Amorphous silica, mean of two determinations,	0.43
Organic substances, including humic acid, vegetable fibre, etc.,	4.19
Hygroscopic water,	1.87
Nitrogen, undetermined.	
	100.00

I. B.

Marl from the same locality, but taken from *ten feet below* the surface of the deposit.

Some of the determinations given will be repeated before the completion of he investigation.

It may be well to state that all filters used by me, both in qualitative and quantitative operations, have been previously washed with chlorohydric acid and water until perfectly pure. The Swedish paper used in this investigation eft after such treatment, in a filter of ordinary size, no appreciable ash. I will also state that the re-agents used by me, are nearly every one prepared by my own hands, in a state of perfect purity, and many according to improved methods not yet given to the world.

H. W.

Resembles I. A. in its appearance, and in its behavior under the influence of heat in a close tube, and on platinum, except that it does not assume the spheroidal state, nor become caked together on cooling. Water boiled upon the marls acquires the same color and odor as from I. A., and becomes neither acid nor alkaline in its reaction. Solutions of the marl in dilute acids possess a dark amber color, and a strong smell of *formic acid*, indicating the presence of the imperfectly known products of the decay of vegetable tissue called ulmine, ulmic acid, etc. Heating with a little excess of nitric acid partly discharges the color.

The ingredients of this variety are:—

1. Soluble in water.		
Sulphate of lime, considerable.		
Ammonia-humate of lime, Chloride of calcium, Chloride of magnesium, Chloride of sodium,	traces.	
2. Soluble in chlorohydric acid.		
Lime,	50.38	Equivalent to carbonate of lime, 89.97 p. c.
Magnesia, with a trace of oxide of manganese,	0.36	Equivalent to carbonate of magnesia, 0.76 p. c.
Carbonic acid,	38.90	
Combined water, Organic acids, by loss.	4.34	
Sesquioxide of iron, with trace of alumina,	0.16	
Phosphate of lime,	0.66	
3. Insoluble in chlorohydric acid.		
Amorphous silica,	0.37	
Organic substances, including humic acid, decayed vegetable fibre, etc.,	3.54	
Hygroscopic water,	1.29	
Nitrogen, undetermined.		
	100.00	

On examination and comparison of the results of these two analyses, several considerations present themselves. In the first place, the presence of soluble salts of lime is an unexpected result. It is unfortunate that time has not yet allowed determinations to be made of the quantities of these soluble salts which are present, but their presence at all in appreciable quantity is of much practical importance. It is in the form of soluble salts only, that lime can act directly as an aliment of plants, that is, in this form only can it be taken up by their rootlets. Farther investigation will probably indicate practicable means of increasing the production of these soluble salts, and of thus greatly augmenting the value of such marls as fertilizers.

Lime, however, is not the only ingredient of importance indicated by the analyses. Nearly every other substance found to be present has more or less influence. The magnesia, oxide of iron, phosphate of lime, and amorphous silica are all absolutely necessary constituents of all fertile soils, while the organic acids, and other products of vegetable decay, which appear to be present in quite important quantity (six or seven per cent.), also contribute indirectly their influence. The organic acids, especially, undoubtedly act by forming compounds with lime, and other bases present, which are soluble in the liquids of the soil, thus necessitating their introduction into the circulation of plants by the endosmotic absorption of the roots; and if the now mooted question, which will probably receive some discussion in future reports, whether the nitrogen of vegetable tissues be derived from ammonia or not, admits of an affirmative decision, the organic acids must also act indirectly, though powerfully, by retaining the ammonia produced during the decay of the animal matter of the shells, in a highly soluble form, and also by absorbing atmospheric ammonia, or even, as indicated by Mulder,* through the development of ammonia by the combination of the nitrogen of the air with the hydrogen produced by their own decomposition. It will be

* As quoted in Loewig's "Chemie der Organischen Verbindungen," i., 474.

observed that the analyses indicate the presence of ammonia, derived undoubtedly from the decay of animal tissues, the proportions of which, however, have not yet been determined, both from deficiency of time and want of the necessary appliances.

The *amorphous silica*, whose presence is shown by the analyses, merits a few words of comment. It is the ingredient in soils which furnishes to many plants, especially to the cereals, such as corn, wheat, etc., the *silica*, which is absolutely necessary to the formation of their stalk or stem. Silica, which is the most abundant of all mineral substances, forming certainly more than one half of the mass of the earth, so far as the latter is known, occurs in soils in three different forms; first, in the crystalline form, as quartz, sand, etc., in which form it is wholly insoluble, and may be considered inert, so far as the nutrition of plants is concerned; secondly, in combination, in fragments of feldspar, hornblende, and other silicates, in which it is also comparatively inactive; and thirdly, as amorphous or *soluble* silica, or *opal*, as it is called by mineralogists, the only form of much importance in agriculture, since in this form it is soluble in the liquids of the soil. Far too little attention has been paid in analyses of soils and fertilizing minerals to their content of opal or soluble silica, whereas a soil may be rich in every other necessary ingredient, and yet, if deficient in this respect, be perfectly sterile for many crops; a remark which may indeed be made with reference to each and every one of the soil-constituents which are required to the building up of vegetable structures; these substances bearing precisely the same relation to the plant as the mineral ingredients of the bones do to the animal, or as the constituents of the shells do to the egg, being consequently just as absolutely indispensable in the one case as in the other.

This subject of the alimentation of plants will of course be repeatedly resumed in future reports, based, it is hoped, upon far more extended investigations of fertilizing materials, as well as of soils, than this one, and it is not, therefore, considered

advisable to enter upon any extended discussion of the subject at present. Two reliable analyses, however, of the grain and straw of wheat, made by Weber, in the laboratory, and according to the method, of H. Rose,* will be quoted here, in order to furnish an idea of the mineral ingredients whose presence in the soil is necessary to the nutrition of that grain.

	In the grain.	In the straw.
Percentage of ashes found, .	1.28	3.82
Constituents of ash.		
Potash, ...	23.18	0.68
Soda, ...	3.09	
Lime, ...	3.23	6.93
Magnesia, ...	11.75	1.69
Sesquioxide of iron, .	1.11	0.99
Sulphuric acid, . . .		0.74
Amorphous silica, . .	1.18	67.90
Phosphoric acid, . . .	46.36	5.05
Chloride of potassium, . .		15.13
Chloride of sodium, . .	10.00	0.89
	100.00	100.00

One of the many prominent points of interest here presented, is the large quantity of silica found in the wheat straw, (sixty-eight per cent.), insomuch that, the whole content of ash in the straw being 3.82 per cent., a simple calculation shows that a ton of such straw would contain more than fifty pounds of silica, and would require more than six tons of the marl I. A. to satisfy it with this element in its nutrition. So that upon a soil already deficient in amorphous silica, such marl, unless applied in a very large quantity, would not furnish it in the requisite proportion. Weber's analyses show also other ingredients in the wheat ashes, which do not exist in the marl, showing very clearly that a farmer who should attempt to restore exhausted wheatlands by the use of such a marl alone, would stand several chances of disappointment,

* Liebig & Kopp's Jahresbericht, für 1849, p. 656.

from the deficiency in the soil of necessary ingredients, unknown to him, which are not contained in the marl. These considerations illustrate how analyses of soils, when properly executed, as very few, it may be asserted, have been, may be of very high value to the agriculturist.

A comparison of the results of the two marl analyses, in consideration of the different depths from which they were taken, is interesting, and will be more so, when determinations of the quantities of the several soluble salts and of the nitrogen shall have been obtained. The main differences between the two are in the nature of the soluble mineral ingredients, which, in the surface-marl I. A., are principally chlorides, and in that from the lower part of the deposit I. B., principally sulphates; and in the organic matter, which, in the surface-marl, has been more altered by the action of atmospheric oxygen. More extended investigation in this direction will undoubtedly develope important practical results as to the selection of the marl, and its treatment preliminary to use.

Another result of the above analyses of Mr. Bonnell's marl, worthy of attention, is the large proportion of carbonate of lime which it contains, very few of the ordinary calcareous marls being equally rich in this ingredient. In fact, after deducting the water and organic matter, both of which would be expelled in burning it for lime, it contains about ninety-nine per cent. of pure carbonate of lime, and would undoubtedly burn into a very pure and excellent lime for building, and all other purposes.

II. A.

A grayish marl, taken from *four* feet below the surface of a deposit on the land of Isaac Coles, Montague Township, Sussex County.

A qualitative examination only of this marl has yet been attempted. It appears to resemble II. B. in every respect, ex-

cept in containing much less phosphoric acid, sesquioxide of iron and alumina, and more vegetable remains.

II. B.

A dark gray marl, from the same locality as II. A., but taken from *eight* feet below the surface.

When heated in a close tube, it behaves, in every respect, precisely like I. A.; also when heated upon platinum, a repulsive force for the metal being developed as in the case of I. A. The ignited marl evolves with chlorohydric acid a fœtid smell of sulphohydric acid, and with acetate of lead paper a strong reaction of the same is obtained. This was at first attributed to the presence in the charred mass of sulphide of calcium, proceeding from deoxidation of the considerable quantity of sulphate of lime found in the marl by the organic matter during the ignition, but it was found that the same evolution of sulphohydric acid took place from the substance when charred after complete removal of all traces of sulphates by long washing with water. It could therefore arise only from the presence of *sulphide of iron*, and as no traces of sulphohydric acid could be obtained from the unignited marl, bisulphide of iron, or *iron pyrites*, must be the ingredient in question, being converted into protosulphide by the ignition.

Water boiled with this marl acquires a yellowish color, and a strong smell like that in I. A., but also resembling some kinds of stagnant vegetable mud, remaining, however, perfectly neutral in reaction. Acid solutions have a light amber color, and smell somewhat of formic acid.

Its ingredients are as follows:

1. Soluble in water.

Sulphate of lime, large.

Ammonia-crenate of lime,
Ammonia-apocrenate of lime, } small.

Chloride of sodium, considerable.

Chloride of magnesium, Chloride of iron,	traces.	
2. Soluble in chlorohydric acid.		
Lime,	9.71	Corresponding to carbonate of lime, 17.34 per cent.
Magnesia,	0.42	Corresponding to carbonate of magnesia, 1.09 per cent.
Carbonic acid,	7.25	
Combined water, Organic acids, by direct determination,	3.19	
Sesquioxide of iron, mean of two determinations,	1.28	
Alumina, mean of two determinations,	2.12	
Phosphate of lime,	0.80	
3. Insoluble in chlorohydric acid.		
Amorphous silica,	1.21	
Organic matter, humus, decayed vegetable tissues, etc.,	5.52	
Coarse sand, with *debris* of minerals containing silica, alumina, oxide of iron, and magnesia, which may be considered as inert matter, Iron pyrites,	66.57	
Hygroscopic water,	2.08	
Nitrogen, undetermined.		
	100.25	

A most remarkable and wholly unexpected result of this analysis is the detection of *iron pyrites* in the marl, and from the fact of finding it also in another of the marls whose analysis is given below, the presumption would seem to be, that it is probably present in many of these deposits. Farther examinations will decide this point. In the mean time, its presence in these two marls can only be looked upon as highly favorable to their availability as fertilizers.

From the presence of an excess of carbonate of lime, it is impossible that any of the protosulphate of iron, formed by the

oxidation which iron pyrites, in the form in which it occurs in these marls, undergoes on exposure to the air, and which might be injurious to the soil, should exist in the mass without being immediately decomposed, with the formation of the powerful fertilizer, sulphate of lime, or *gypsum*. And that this action is continually going on in the mass, is indicated by the large quantity of sulphate of lime actually found in the aqueous solution. It may be said with certainty, with regard to such marls as these, that the longer they are exposed to the open air, in a moist state before use, the more powerfully fertilizing they will become. So that an important point as to the preliminary treatment of these marls is thus already definitely decided by these brief investigations. The origin of the iron pyrites in these deposits is a very curious question, and, in fact, the whole subject is one of great interest, and will amply repay fuller investigation. The presence of the iron pyrites was discovered at too late a day to admit of any attempt at determination of its quantity.

The quantity of carbonate of lime in this marl, as also in the one next described, is small, but on account of the presence of the sulphide of iron, and the continual formation of gypsum, which must consequently take place on exposure to the atmosphere, they will, in all probability, be found fully equal, if not much superior, in power, to the marl first described, although they will not be nearly so lasting in their action.

The other ingredients of this marl are not without importance, the proportions of amorphous silica and phosphate of lime, for example, being much greater than in the marl No. I.

III.

Marl from the land of Isaiah Vannetten, Montague Township, Sussex County, taken from four feet below the surface of the deposit.

A very dark colored, moist, peaty mass, containing remains

of decomposing rootlets. On drying by exposure to the open air, pulverizing and sifting, it was found to contain transparent silicious particles. When heated, it blackens, smokes, and burns with flame, leaving a residue which before the blow-pipe assumes a reddish color, from the presence of oxide of iron. When heated in a close tube, it gives off much water, with ammoniacal and tarry products, and a strong tobacco-like odor like I. A. The charred mass, as in II. B., evolved with chlorohydric acid a large quantity of sulphohydric acid gas, and as in the present case no sulphates are present, which could be converted into sulphides by the organic matter on ignition, there can be no question of the presence of iron pyrites in the marl, even without further examination.

Water boiled with this marl acquires a yellowish color, and an odor similar to that in I. A., remaining perfectly neutral. Acid solutions have a dark amber color, which is not perceptibly discharged by boiling with nitric acid; and a very strong smell of formic acid.

The contents of this marl are:—

1. Soluble in water.		
Chloride of calcium, Organic salts of lime,	large indications.	
Chloride of sodium, Chloride of magnesium, Chloride of iron,	traces.	
2. Soluble in chlorohydric acid.		
Lime,	8.45	Corresponding to carbonate of lime, 15.09.
Magnesia,	0.43	Corresponding to carbonate of magnesia, 0.90.
Carbonic acid,	6.12	
Combined water, Organic acids, by loss,	3.62	
Sesquioxide of iron, Alumina,	2.49	
Phosphate of lime,	0.31	
3. Insoluble in chlorohydric acid.		
Amorphous silica,	1.15	
Organic matter, consisting of		

vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.	8.20
Iron pyrites, Inert matter consisting of coarse sand, with silicates of alumina, oxide of iron and magnesia,	66.97
Hygroscopic water,	2.26
Nitrogen, undetermined.	
	100.00

The same remarks appended to marl No. II., apply with equal force to this, the two being almost precisely similar in composition. One important difference, however, is that this marl contains no sulphate of lime. On exposure, however, to the air, it cannot fail to be developed in the mass sooner or later. The proportion of phosphate of lime, also, is much smaller than in II. The proportion of decayed vegetable matter and of organic salts of lime is unusually large in this marl, and has undoubtedly been the means of protecting the iron pyrites from oxidation.

IV.

Calcareous sinter, from Metler's farm, Dingman's Ferry, Sandiston Township, Sussex County.

A yellowish gray mass, of spongy structure. It is naturally quite pulverulent, but on exposure to the atmosphere becomes so much more so as to be easily crushed to powder between the fingers like coarse chalk, a property which, of course, much enhances its availability as a fertilizing substance. When heated in a close tube, it gives off a faint trace of ammonia, with a little water. The ignited mass, on solution in chlorohydric acid, leaves a slight black residue, which, besides amorphous silica, contains carbon, thus indicating the presence of

organic matter in the substance. Water boiled with it evolves an odor like that of moist chalk, acquires no perceptible color or reaction, but dissolves salts of lime in appreciable quantities. Acid solutions have a light amber color and no smell.

The contents are:

1. Of the solution in water.

Chloride of calcium, considerable.		
Ammonia-crenate and Ammonia-apocrenate of lime, Chloride of sodium, Chloride of magnesium,	traces.	

2. Of the solution in chlorohydric acid.

Lime,	54.57	Corresponding to carbonate of lime, 97.44.
Magnesia,	trace.	
Carbonic acid,	42.57	
Sesquioxide of iron,	0.37	
Phosphate of lime,	0.22	
Organic acids, Combined water,	undetermined.	

3. Of the insoluble residue.

Amorphous silica,	1.00
Organic matter (humic acid),	0.17
Hygroscopic water,	0.32
	99.22

An analysis of a calcareous sinter, from this same locality, given by Prof. Rogers in his report, page 109, where he scribes it under the name of *travertin*. The results do not er much from mine, except that no detection or determina- of the important ingredient, amorphous silica, was effected. presence of phosphate of lime also was not noticed by Rogers, owing to the entire want, at that time, of any od of detecting this highly valuable ingredient with cer- y, except when present in large quantity. The specimen zed by Prof. Rogers also does not seem to have been of purity with mine, his analysis indicating but 93.58 per of carbonate of lime, while mine gives 97.44 per cent. e considerable quantity of chloride of calcium (also not

observed by Prof. Rogers), which is indicated by my analysis, is a very interesting fact. It is to be regretted that a specimen of the water from which this calcareous deposit was formed, was not also collected, in order that its composition might be compared with that of the deposit itself. Farther remarks upon the presence of the chloride of calcium are reserved until this can be done, and also a determination made of the amount of this salt contained in the mineral.

As remarked by Prof. Rogers, this calcareous sinter should give, when burnt, a very white and good lime.

V.

Calcareous sinter from the farm of Benjamin P. Van Sickles, Petersville, Sandiston Township, Sussex County.

Stalactitic in its structure, and contains small pebbles of quartz and sandstone. When heated upon platinum, it presents the same curious phenomenon of repulsion as I. A. The presence of organic matter was indicated by a brown color of the residue left after solution of the ignited substance in chlorohydric acid, which brown color disappeared before the blowpipe. The solution formed by boiling water with the pulverized substance has a smell like moist chalk, no color or alkaline reaction, and contains much chloride of calcium and other chlorides. Acid solutions have no smell, and little or no color.

1. Solution in water contains:

Chloride of calcium, considerable.
Chloride of sodium,
Chloride of magnesium, } traces.
Organic salts of lime.

2. Solution in chlorohydric acid:

Lime,	43.68	Corresponding to carbon. lime, 78.01.
Magnesia,	0.14	Corresp'ng to carb. of magnesia, 0.29.
Carbonic acid,	34.44	
Sesquioxide of iron, with trace of alumina,	0.80	
Phosphate of lime,	0.43	

Organic acids, Combined water,	undetermined.
3. Insoluble residue:	
Amorphous silica,	0.38
Organic matter,	0.20
Inert matter, consisting of silica, with traces of oxide of iron, alumina and magnesia,	19.39
Hygroscopic water,	0.36
	99.82

Work has been commenced also upon some other minerals, comprising some limestones and marbles, but the results are not complete enough to possess much interest, and I shall not therefore present them at present.

I am,

Very respectfully,

HENRY WURTZ,

New Jersey State Chemist, Mineralogist and Metallurgist.

REPORT

OF EGBERT L. VIELE, TOPOGRAPHICAL ENGINEER.

HAVING been intrusted in June last with the duty of preparing a reliable map of the State, upon which could be accurately delineated the results of the geological explorations, it became my first care to determine the most feasible, and at the same time most economical method which could be pursued in prosecuting the undertaking. To this end, an examination was made of the records and maps deposited in different county seats, and also those on file at the State capital. From these no information could be obtained beyond that which is laid down on an existing map of the State, which map is merely a compilation from those records, showing the principal towns and roads, but exhibiting no reliable physical features, so important to the proper exposition of geological formations. Under these circumstances it was evident that an actual survey alone could furnish the map required. A plan based upon the extension of the coast survey over the State was submitted to the Governor, and discussed by several of the most eminent men in the State, then attending a session of the supreme court at Trenton. It was conceded to be the most judicious plan that could be followed, and adopted by the Governor as being the only one which would give to the State such a map as its geographical position and its great mineral wealth required.

The method pursued in a survey of this nature is as follows: A line from three to ten miles in length is measured with

TRIANGULATION

on a Base measured in

Lafayette Township.

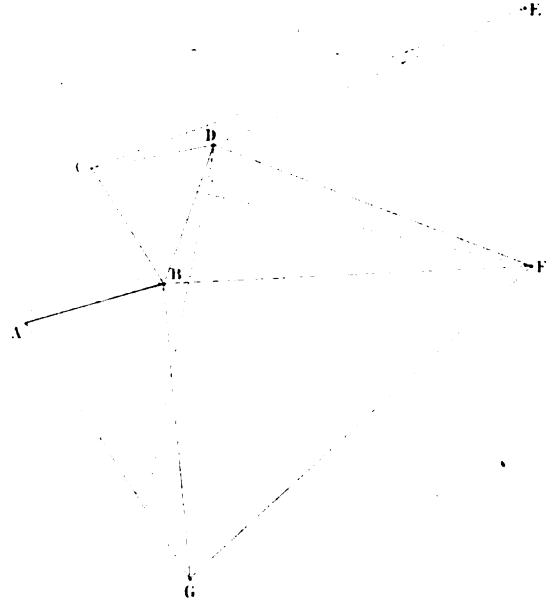


Table of Reference

A B Baseline in Lafayette Township
D Signal on Pennshill
E near Deckertown
F near Hamburg
G on the Franklin mountains
H on Pellums head
I on Smithill near Newton

Scale 1:80000

miles

the greatest care and accuracy upon a plain as nearly level as can be found. This is called a *base line*, from each extremity of which, by means of a theodolite, the angles are measured, which are included between several prominent surrounding objects previously selected as trigonometrical points. From each of those points the angles are measured between the lines joining the points and the extremities of the base line. There is thus formed a series of triangles, from the known parts of which the unknown are determined by calculation, and we thus ascertain the length of the sides of the triangles or the distances between the trigonometrical points. From these sides as bases other trigonometrical points are determined, until the entire tract of country to be surveyed is covered over with a network of triangles, of as large a size as is consistent with the means employed. This is called a primary triangulation, within which a series of secondary triangles is formed in the same manner. The interior details between the secondary points are filled in by means of the plane-table. These details consist of the contour lines of the elevations, or horizontal sections of the hills, taken at equi-distant intervals—the direction and sinuosities of the water courses; the houses, roads, farm lines, etc. Observations for latitude and longitude are made at several of the most conspicuous stations, from which the geographical position of all the points can be determined, and their places projected on the map with extreme accuracy.

For the purpose of the Geodetic Survey, the coast of the United States has been divided into eleven sections, in each of which a base line of from five to ten miles is measured. The coast of New Jersey is included in the second of these sections, the base of which is on Fire Island. The primary triangulation extends across the State from Amboy to Trenton, and down the Delaware River. The secondary triangulation follows the same course, and also extends along the whole coast. About two thousand square miles of topography have been completed, based on this triangulation. Observations for latitude and azimuth have been made at a number of stations of the primary triangulations. The difference of latitude,

longitude, and azimuth, between these and the other stations have been compiled, and the results published in tabular form, giving the names of the several stations or triangulation points, the latitude and longitude of each station, and the distances between the several stations.

The course to be pursued in completing the survey of the State is a very plain one: simply to begin where the coast survey left off, carry out the triangulation, and fill in the topography. Half the labor and expense of the undertaking is saved to us, by what has already been accomplished. The records of the work done are complete for every step of progress, and a monument of some kind marks every triangulation point. Had the appropriation of last year been sufficient, operations would have been commenced on a side of the coast survey primary triangulation as a base, and the topographical parties would have worked from the centre of the State to the north and south simultaneously. Under the circumstances, however, it was deemed most judicious to show as much topographical and geological development as possible, in the short time that would elapse before the meeting of the Legislature, in order that the whole subject might be presented in a clear light. To this end, the boundary line between New York and New Jersey was selected as the base of operations, on the supposition that this line, having been laid down by a joint commission, offered a well-defined base line. Time, however, and individual carelessness, had served to obliterate or destroy every vestige from the Delaware to the Blue Mountains; even the initial point was wanting. A serious delay occurred in re-establishing this line so far as the records that could be obtained enabled it to be done. The line determined on coincided with the one formerly regarded as the boundary line in the division of property bordering upon it; although, during the last few years, it had been shifted to one side or the other, according to the ideas of the local surveyors. Having established a starting point, levelling for a geological section was commenced along the boundary line, and a base for topography was measured in the township of Montague. The

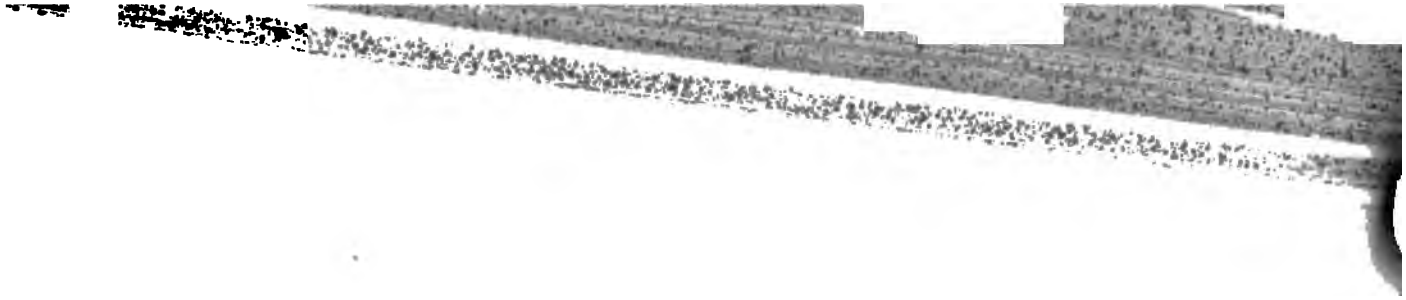
principal points were established by a reconnoissance, in order that the topography might be checked by a secondary triangulation when a theodolite could be procured. A second base line was afterwards measured in the township of Wantage, and the same course pursued as in Montague, and so on for all the townships that were surveyed. But one plane-table was in use until September, when one was borrowed from the Coast Survey, and afterwards a theodolite from the same source. From the beginning of the work, Professor Bache, the Superintendent of that Survey, has taken a cordial interest in its progress, and expressed a willingness to aid it by any means in his power.

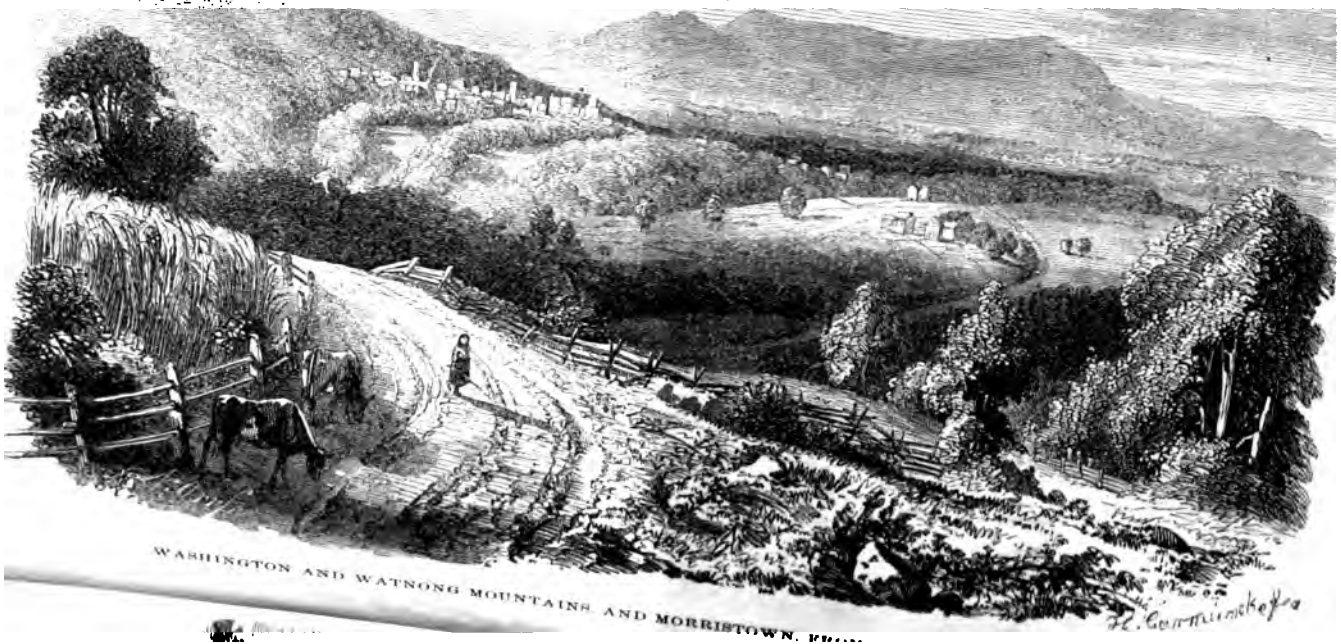
A summary of the operations of the past season is as follows:—The party entered the field on the eleventh of July, consisting of three principal assistants, aided by four volunteers, who gave their services in return for learning engineering. Three more assistants were added when the instruments were received from the Coast Survey. On the 30th of November the field operations were brought to a close. During that period, the parties completed three hundred and sixty-one miles of topography, (being three fourths of the county of Sussex,) and seven hundred miles of levelling for geological sections, besides many minor details. In consequence of the late period at which the theodolite was received, and the inadequacy of the means, the complete triangulation of the county was not accomplished, but enough was done to test the general accuracy of the topography. A sketch of this accompanies the report. Since the parties left the field, a sufficient length of time has not elapsed to complete in the office all of the work which has been done, but so much as may be mapped at the time the subject occupies the attention of the Legislature, will be forwarded to Trenton for inspection. The scale upon which it is proposed to execute the map, is 1–80,000, the same as the published maps of the Coast Survey, and as the topographical map of France. This is somewhat less than one inch to the mile, which is the scale of the ordnance map of England. The scale proposed for the county maps is 1-30,000, or about two inches to the mile.

It might appear almost superfluous to enlarge upon the nature and importance of this work, considered with reference to the intrinsic value of a topographical map of the State. The great attention which has been given in this country, during the last few years, to the study of physical geography, and the rapid strides of education and intelligence, has created a demand for something more than mere guide maps of the different States of the Union. The National Legislature, true to the impulse of the times, has nobly responded to the efforts of science—hundreds of thousands of dollars have been freely expended in exploring and preparing charts of the seaboard. A network of triangles covers the coast from Maine to Texas—minute soundings have brought to light the hidden rock and treacherous shoal. The capacities of the inlets, rivers, and harbors of the Atlantic coast have been determined, and a basis of accurate survey established, which the States bordering on the ocean are invited to take advantage of, and continue this great work, so that the States adjoining them may take it up and continue it on until it meets a corresponding effort from the Pacific side. Thus giving to the country and to the world what England commenced a hundred years ago—what France, Italy, Austria, Norway, and Sweden and Russia, have spent millions to obtain, viz:—A correct topographical map, from which future generations may learn the nature and extent of the vast resources, developed and undeveloped, of this favored land. Under the auspices of an enlightened legislation, the State of New Jersey has been the first in the Union to commence this undertaking on purely correct principles. Its completion will be an era in her history, and a lasting monument of the intelligence of her people.

EGBERT L. VIELE,
Topographical Engineer.

DR. WILLIAM KITCHELL,
State Geologist and Superintendent.





WASHINGTON AND WATNONG MOUNTAINS AND MORRISTOWN.

SECOND ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF NEW JERSEY,

FOR THE YEAR 1855.

TRENTON:
PRINTED AT THE TRUE AMERICAN OFFICE.
1856.

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WOOD CUTS.

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ERRATA.

On page 45, tenth line from bottom, read "are" for "is."

" 46, sixteenth line from top, read "were" for "was."

" 118, eighth line from bottom, read "northeasterly" for "southeasterly."

" 119, sixteenth line from bottom, read "considerable" for "inconsiderable."

" 128, fourteenth line from bottom, read "Sussex" for "Passaic."

" 130, third line from bottom, read "northeastern" for "northwestern."

" 143, sixteenth line from bottom, read "southeastern" for "southern."

" 163, fifth line from bottom, read "worked at the present," instead of "worked the present."

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IS EXCELLENCY,

RODMAN M. PRICE,

Governor of New Jersey.

SIR:

ave the honor herewith to submit to you the Second Annual Report
e Progress of the Geological Survey of the State of New Jersey, for
ar 1855.

Very respectfully, your obedient servant,

WILLIAM KITCHELL,

Superintendent of the Geological Survey of New Jersey.

WARK, N. J., January, 1856.

[redacted]

REPORT

ON THE

ORGANIZATION OF THE SURVEY,

AND FINANCES.

REPORT.

In my last Annual Report, the plan adopted for prosecuting the Survey divided it into four principal departments:

1st. The Topographical and Trigonometrical Department:

2d. The Geological Department.

3d. The Palæontological Department.

4th. The Chemical and Mineralogical Department.

It was then stated that the object of the topographical department was to furnish a correct and minute topographical map of the State, on a scale sufficiently large for the accurate delineation of the geological features of the State, as well as for the proper presentation of data from which sections representing the relative position and thickness of the various formations of rocks, could be constructed.

Deeming this the true basis, or ground work, of correct geological research, it has been my chief aim to promote its rapid advancement; and, consequently, the greater part of the appropriation made at the last session of the Legislature has been devoted to it. By reference to the report of Mr. E. L. Viele, the State Topographical Engineer, it will be seen that no time has been lost in organizing parties, and sending them into the field, as early as the season would allow. In order that the work might advance with an equal pace, both in the northern and southern divisions of the State, the same number of parties was sent into both divisions; and, subsequently, a triangulation party was organized, the operations of which, in connection with those previously conducted by the U. S. Coast Survey, have extended

the triangulations nearly over the entire State. For the purpose of rendering each topographical party available in advancing the geological researches, as far as time could be appropriated, and the nature of their labors would allow, the following instructions were given to the first assistant of each:

"You are hereby instructed, in addition to your duties as assistant engineer, to make the following observations and investigations in that section of the State over which your labors extend:

"1st. PHYSICAL GEOGRAPHY. Describe the physical features of each township, embracing its mountains, hills, elevated lands, plains and valleys; their extent, direction, and height; their declivities or surfaces—whether level, gently inclining, or undulating, or precipitous; whether cultivated or uncultivated; covered with rocks in place, drift, or alluvion. Note, particularly, the most elevated mountains and hills, and describe the nature and extent of the scenery from their summits. Ascertain with precision as many elevations above mean tide, as well as the water level in the vicinity, as possible; especially at marl pits, quarries, mines, and wherever useful minerals are found. Describe all rivers, lakes, ponds, and springs; their origin and course; extent, depth, velocity of current, availability for water power, or other useful purposes; by what animals inhabited, and their abundance, etc.

"2d. GEOLOGY. Examine and note minutely all geological formations, viz: The different varieties of rocks, including all layers of sand, gravel, clay boulders, etc.; their strike, dip and extent; and represent their relative position by sections, diagrams, and drawings; and delineate the boundaries of each formation on the map; describe their lithological, mineralogical, and chemical characters; their texture, hardness, cleavage, and durability; their resistance to atmospheric agencies, and adaptation to economical purposes, as materials for building, paving, macadamizing, etc. Examine their constituent minerals; their

form, size, color, hardness, relative position, and abundance; their resistance to the various agencies to which they are exposed —whether one is more easily acted upon than another.

"3d. METALLIFEROUS DEPOSITS. Search for, and examine, minutely, all metalliferous deposits, and locate them on the map. Determine their character, whether superficial, stratified, or unstratified; if unstratified, whether they are regular or irregular; if regular, whether they are segregated, gash, or true veins; whether they are of igneous or aqueous origin. Describe their geological position; the character of their wall rocks, their strike, dip, thickness, and extent; the character, quality, and abundance of the ore, and its accessibility for mining. Examine, and locate all mines, quarries, and deposits of fertilizers, such as marl, phosphate of lime, peat, and muck; ascertain their facilities for being extracted, and the best means of placing them in market. Ascertain the names of all mines, quarries, furnaces, forges, and rolling mills; the names of their owners; by whom, and to what extent, they are worked; the use and disposal that has been made, and is now made, of their productions. Collect historical data concerning them, and all other matters of interest in reference to them, from their commencement to the present time.

"4th. SOIL. Describe the character of the soil, whether consisting of sand, gravel, clay, and vegetable matter, or any mixture of them; its adaptation to the growth of particular plants; the usual crops grown upon it; the average yield per acre; and the means resorted to for increasing its fertility.

Examine the natural growth of trees, shrubs, and plants; their species and abundance.

"5th. METEOROLOGY. Keep a register of the weather, prepared from daily thermometrical and barometrical observations. Describe all storms and showers; their commencement, duration, and severity. Note localities where lightning has struck; together with its effects and attendant circumstances. Make inqui-

ries in regard to the prevalent diseases of particular districts, such as intermittent and remittent fevers, etc; the season of the year at which they generally prevail, and to what cause they may be ascribed. Ascertain if any meteorological observations are, or have been, regularly made in the vicinity, and for what length of time, and by whom made.

"6th. SPECIMENS. Collect three suites of specimens of all the varieties of rocks, minerals, ores, marls, clays, sands, peats and fossils, found in each township. Let them be uniform in size, viz: four inches square, and two inches thick, except when isolated or grouped crystals and fossils require specimens of greater or less dimensions. Obtain them directly from the formation, deposit, or mine, and let them possess fresh and clean surfaces.

"The rocks, clays, marls, peats, sands, and fossils should be characteristic of formations, strata, beds and layers. The minerals, ores, rocks, etc., of economical value, should be characteristic of localities, such as deposits, mines, and quarries.

"Label each specimen (in accordance with the accompanying label) with its name, (when known) its precise locality, date of collection and name of collector; and carefully wrap it in strong thick paper.

"Let the label of each specimen refer to the particular page of a note book on which it is described. Carefully pack each series of specimens in strong boxes, in such manner that their surfaces cannot come in contact, or be scratched or injured by rubbing together. The weight of each box should not exceed one hundred and fifty pounds.

"Choice specimens of crystallizations and fossils should be wrapped in cotton and packed separately.

"Prepare a list of specimens in each box, numbering each to correspond with a number on the outside of the wrapper, and place it on top of the specimens, when the box is filled.

"Mark distinctly, and number, each box to correspond with

ote book in which the specimens are described, and address follows: [————————]

Whenever an opportunity may allow, collect specimens of ral History, such as plants, birds, animals, reptiles, fishes, s, bugs and infusoria. Preserve and pack them carefully, ordance with the accompanying directions."*

organizing each plane-table party, it was made an object to a first assistant, who, being somewhat acquainted with gical research, should render as much aid as possible in lying with the above directions. Although there was some ulty in procuring a competent assistant for each party, still, little instruction in the field, the majority of them have able to render efficient service in collecting a fund of in-tion, which may be made available in various ways.

the object of the survey is not simply a scientific descrip- f the topographical and geological features of the State, lso their economic relationship, it has been deemed advisa- embrace, in this report, an enumeration and description internal improvements of the State, together with all the s to the true mode of opening every portion of its territory veloping its resources.

ending to conduct, in person, the geological researches in orthern division of the State, I entered the field as early spring as the weather would allow, and made a general noissance of Morris County, and of a part of Passaic and en. But finding that the general superintendence deprived the time so essential to the rapid advancement of the ed examinations, an assistant geological party, consisting r. Ernest Haeusser, assisted by Mr. E. F. Baldwin, was ized on the first of June, and sent into the field, with ctions to make detailed examinations of the azoic rocks of ighlands.

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ections for collecting, preserving and transporting specimens of Natural His- epared for the use of the Smithsonian Institution, 1854.

On the twenty-third of September a party of engineers, consisting of Mr. R. W. Patterson, assisted by Mr. W. Wagner, was organized, and entered the field, in the iron region of Morris County, for the purpose of assisting in making local surveys of its principal mines, and mine tracts. Their labors have resulted in a survey of both the surface and underground workings of the principal mines, from which sections and diagrams representing the nature and position of the deposits, and the extent of their workings, also topographical maps of the Hibernia and Andover mine tracts have been made. Some of these sections are included in the annexed report on the Highlands.

Mr. J. Morris has been engaged during a part of the summer in preparing profiles for geological sections, deduced from notes and surveys gratuitously furnished by Mr. Bassinger, Chief Engineer of the Morris & Essex Rail Road. These sections are reserved for the final reports on the counties of Morris and Warren, now in course of preparation.

Since the termination of the field operations on the first of December last, there has not been sufficient time for collecting and arranging the materials necessary to so systematic a report as could be desired; nor has there been opportunity for making the qualitative chemical examinations belonging to an accurate description of the rocks; and consequently the annexed report on the progress of the survey in the Highlands is submitted merely as a partial statement of the many detailed examinations in this most interesting and important district.

The Assistant Geologist, Professor GEORGE H. COOK, in charge of the southern division of the State, has been actively engaged in prosecuting the field work, as may be seen by the results of his labors included in the annexed report. At intervals, during the year, he has been assisted in his researches by the following gentlemen: Messrs. Nicholas Wyckoff, and Alexander M. Kelvey, who have aided him in running levels for

sections, which are reserved for the final report; Mr. Abram Van Nest, who has assisted him both in the field and the laboratory; Mr. Julius Kock, who has been occupied in making analyses of marls, clays, etc., the results of which are herewith submitted; Dr. P. D. Knieskern, who has been engaged in collecting fossils, his ardent devotion to the study of which, together with his intimate acquaintance with that portion of the State, have enabled him to render very important service in this department; and Mr. William Snowden, who has aided him in the geological examination of Salem County.

In addition to the levels and profiles made by the above named levelling party, Mr. Martin Coryell, Chief Engineer of the Delaware and Chesapeake Canal, has very kindly furnished a profile of this canal, with an account of the green sand stratum through which it passes. Copies have also been obtained of levels on the West Jersey Rail Road, and on the Camden and Pemberton Rail Road, through the courtesy of General William Cook, Chief Engineer of the Camden and Amboy Rail Road.

Thus, it will be seen that the geological department of the survey is in a condition to be completed and reported upon finally, by counties, as rapidly as the topographical maps are finished.

At the commencement of the year, Mr. Henry Wurtz, who is in charge of the chemical and mineralogical department, began to fit up the laboratory with the necessary reagents, and apparatus for making the chemical and mineralogical examination of the minerals, ores, etc., collected by those in the field. The difficulty experienced in obtaining pure reagents from the shops, rendered it necessary to prepare them in the laboratory; and this, together with other hindrances, delayed the commencement of the examination of the specimens, until a late period in the spring. As it was determined to confine the geological researches in the northern division, for the year, to the metalliferous district of the Highlands, it was deemed advisable

that Mr. Wurtz should devote a portion of the season to examining the principal mines of this district, and to selecting specimens therefrom for the State and County Cabinets, as well as for analysis. In accordance with this plan he spent the entire summer season in the field; and the results of his labors, embodied in the report, are of a most interesting and important character, tending not only to benefit the iron masters of this region of the State, in their mining and metallurgical operations, but also adding materially to the fund of chemical and mineralogical science.

The following letter, accompanying the report, will give an idea of the nature and extent of the work now in progress, the results of which must be deferred until the preparation of the county reports:

NEW JERSEY STATE LABORATORY,
Trenton, January 1, 1856.

To DR. WM. KITCHELL, STATE GEOLOGIST:

SIR:—On presenting my Report for the last year, it is expedient that I should make a few remarks by way of explanation.

It was hoped that it would be possible to introduce into the present report a considerable quantity of material in addition to that which has been reported, and among other things, the results of an extensive series of thorough and elaborate quantitative analyses, which are now in progress, of the ores of many of the mines reported upon. The time, however, has been so consumed by the labor required for reducing into orderly and intelligible shape the great quantity of materials gathered in this department during the past season, so as to enable me to show the nature of the work begun, and the progress that has been made, that after making every possible exertion, I am compelled reluctantly to defer the analyses until a future report.

It is also a part of my intention to collate and condense, as

much as possible, into tabular forms, the heterogeneous mass of observations which I have made upon the mineralogy of the iron region, and upon the structure of the ore-beds, and thus to present them in such a shape that generalizations may be made, and principles deduced, to serve as guides in our future operations; and in this connection to bring forward, also, a number of general views and theoretical considerations which have occurred, bearing upon the important subject of the origin and mode of formation of the ore-beds.

Want of time, however, has made the introduction of these things also impossible; and it may be better, moreover, that the publication of such generalizations, and the theoretical views deduced from them, be postponed until the explorations of another season shall have furnished us with a still larger and firmer foundation of facts upon which to base our superstructure of hypothesis.

Besides all this, there is in my possession a considerable quantity of actual material of a miscellaneous character, which it has not yet been possible to arrange in a presentable shape, and which must also be introduced into a subsequent report.

No light portion of the labor has been the quantitative examination of the minerals, which has been carried to so great a degree of minuteness that I may say that scarcely an assertion as to the specific identity of a mineral occurs in the report, which does not rest upon analytical evidence. In every case where reasonable doubt could exist, it is sufficiently expressed in the context. For efficient assistance in this important part of the work, it is just that I should acknowledge my especial indebtedness to Mr. Howland Bill, pupil in this laboratory, by whom a large number of the analyses were made.

I am, very respectfully,

HENRY WURTZ,

State Chemist, Mineralogist, and Metallurgist.

The limited time left to Mr. Wurtz was insufficient for him to enter upon, and complete a series of analyses of marls and clays, required by the Assistant Geologist in arriving at reliable conclusions connected with the economic geology of the southern division of the State. Under these circumstances an assistant chemist was employed, who, under the direction of Prof. Cook, has been engaged in the desired investigation, the results of which are included in the report of the Assistant Geologist.

This very important department of the survey being now fully organized, and an ample supply of material collected for examination, every effort will be made to advance its operations as rapidly as the circumstances and the nature of the investigations will allow.

In the early part of the year the palæontological department, until this time vacant, was filled by the appointment of Mr. T. A. Conrad, an early pioneer in palæontological research, not only in this, his native State, but in various States of the Union. From the wide reputation of this gentleman, derived from the results of his labors, both as a minute observer and sound reasoner, the State had grounds for congratulating itself upon an appointment that promised so auspiciously in this very important department. But the condition of Mr. Conrad's health, soon after his appointment, would not permit him to enter upon his duties; and he, consequently, resigned his position in the survey.

A correspondence was then opened with the distinguished palæontologist, Prof. James Hall, who was, at that time, about to visit the Western States, for the purpose of making some researches in the palæozoic rocks of that region. It was impossible to procure his services for the past year, but, since his return, within a few weeks, arrangements have been made to place him in charge of this department. He will be able to devote to the work as much time as the progress in the county surveys will require, together with all that will be necessary for a final report on the palæontology of the State.

Cabinet. During the year about three thousand specimens have been collected for the State and County Cabinets; but as, on the part of the State, no rooms have been provided for their accommodation, much time has been lost in the unpacking and repacking incident to their examination. The specimens, so far as they have been collected, in connection with the detailed geological researches of townships, are now ready for arrangement, and it is very desirable that something should be done as soon as possible, in order that the minerals intended for the local arrangement, viz: by townships, may be classified, and placed in accordance with the preparation of the final report on each county.

Draughting and Engraving. In order that the county maps should, in accordance with the law, be ready to accompany the final county reports, and in order that accuracy of execution and economy should be united, it was deemed advisable to have the engraving performed under our own supervision. As soon, therefore, as the field-work of Sussex County was finished, a map of it was commenced, and is now nearly completed. Maps of counties will, in like manner, be commenced, and carried on, as rapidly as the work in them shall be achieved; and thus, by sections embracing a single county each, the whole State will finally be delineated upon a single map. By causing the maps to be engraved under our own supervision, directly from the plane-table sheets, a great amount of labor and expense has been saved in dispensing with the draughting of the topography upon paper, a task which would have been otherwise necessary. With the same end in view, the various illustrations accompanying the report, have been engraved from transfers made upon wood, directly from the rough sketches, and by the same artist who took them in the field. These illustrations are intended to accompany the final county reports, and are submitted at this time rather as specimens of the style of their execution. They were sketched in the field, and, (with the exception of those taken in Sussex

County, which are the work of Mr. Francis E. Berier,) were drawn on wood by Mr. Herman Carmiencke, and engraved by Mr. N. Orr.

It will thus be perceived that, in the preparation and arrangement of the materials gathered in the field, and elsewhere, everything has been done with a view to the perfection of the county reports, from which, ultimately, a systematic report on the whole State may be prepared.

FINAL REPORTS. The topography of two counties being already completed, and that of several others nearly so; and, the other departments of the survey being in a corresponding state of advancement, the final county reports will be forthwith commenced, and at an early day submitted. The general survey will at the same time be continued, and reports thereon annually presented in accordance with the law.

FINANCES. The following abstract of expenditures includes not only the expenses of the field-work, for which the estimate of last year was made, but also those of the draughting, of the engraving, and of the office, for which a distinct appropriation should be made.*

EXPENDITURES.

Topographical Department - - -	$9,361 91 1-2
Geological Department - - -	5,316 05 1-2
Chemical Department - - - -	2,449 57
Palæontological Department - -	000 00
Miscellaneous, Engraving, etc. - -	810 00
Total - - - - - - -	$17,937 54
Receipts - - - - - - -	$16,000 00
Appropriation - - - - -	$20,000 00

* For particulars, reference may be made to the accompanying vouchers, abstracts, accounts current, and annual return.

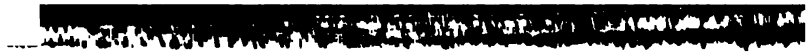
The following estimate is for the prosecution of the survey, both in the office and field, for the coming year:

Topographical Department - - - -	$10,000
Geological Department - - - - -	6,300
Chemical and Mineralogical Department - -	2,700
Palæontological Department - - - -	1,000
Engraving and Draughting - - - -	5,000
	$25,000

As this will be sufficient to prepare the maps and cuts for at least three, and perhaps four counties, in addition to extending the field-work over the greater part of the State, upon which reports may be rendered next year, I would recommend that arrangements be made for the disposal of the County reports either by sale or gratuitous distribution. The latter method does not seem to be the more advisable one, as the demand for the work, under such circumstances, would doubtless exceed the supply. The former method would place it in the hands of all who choose to avail themselves of it, and, at the same time, would reimburse the treasury, sufficiently to defray at least the expense of engraving and printing.

In concluding this report, I would express my thanks and obligations to the numerous friends of the Survey who have rendered assistance in furnishing information, and collecting specimens pertaining to its various departments, as well as to the various branches of Natural History—a subject which, I hope, will at no distant day be added to those now under investigation. Especially do I desire to express my indebtedness to the officers in charge of the several departmens, all of whom have labored with an assiduity and energy indicative of a love of science and the best interests of the State.

WM. KITCHELL,
Superintendent, and State Geologist.



REPORT

ON THE

TOPOGRAPHICAL DEPARTMENT.

DR. WILLIAM KITCHELL, *Sup't Geological Survey:*

SIR:

I herewith submit the report of the Topographical Department of the State Survey, for the past year.

I have prefaced it with a few remarks on the principles upon which the Survey is conducted, in order to make it more comprehensive as well as more interesting.

The report is from its nature incomplete, as it is only in a final report that positive results can be looked for.

The work accomplished will be found to compare favorably with any other of the same nature, both in amount, accuracy, and economy.

Your obedient servant,

EGBERT L. VIELE,
State Topographical Engineer.

REPORT.

The topographical survey of the State has for its object, to furnish a correct basis for the examination and delineation of the geological formations which occur within its limits, and at the same time to supply a complete physical map of every county, exhibiting all the features of the surface.

TOPOGRAPHY.

Topography may be defined as a description of the features of a country, either verbal, written, or represented on a map by means of conventional signs.

The latter conveys to the mind a more perfect idea than any other, since it is an exact copy of nature on a small scale.

In order the more clearly to understand the method pursued in the graphic representations of the surface of the earth, let us conceive a horizontal or level plane to be passed underneath a limited area of ground, and that from every point of the surface perpendiculars be let fall upon this plane. The feet of the perpendiculars, or the points of their intersection with the plane, will be the horizontal projections of all the points on the surface, and will form by their connection a correct representation of the natural and artificial features of the country.

If this representation be reduced to a smaller scale, and drawn upon paper, we shall have a topographical map upon which we shall see traced the sinuosities of the streams and roads, the outlines of the woods, the boundaries and extent of the fields and enclosures, the localities of the houses, etc.

That the inequalities of the surface may be clearly represented, we resort in the same connection to a system of contour

lines, which are the lines in which the surface of the hills would be intersected by a series of imaginary horizontal planes, taken at equidistant vertical intervals.

These lines of intersection are projected upon the principal horizontal plane or plane of reference. The spaces between the contour lines are filled by short vertical lines of greatest declivity, drawn normal to the upper curves, and terminated by the next lowest successively.

It is evident that the nearer the lines approach each other in projection, the greater the declivity of the slope.

THE PLANE TABLE.

The most useful and convenient instrument used in delineating topography is the plane table, which consists principally of a small rectangular tablet, about one foot square, secured to a tripod, and having an arrangement for making it level. A sheet of paper designed to receive the map, is stretched upon the surface. Accompanying the table is a ruler, to which is attached a telescope, whose line of collimation is in the same vertical plane with the edge of the ruler.

To use the table it is necessary to determine at first by measurement the exact length of a line upon the ground. Then placing the table at one extremity of this line we fix with a needle that point on the table which corresponds with the point at which we stand. Resting the edge of the ruler against the needle, we direct the telescope to the other extremity of the line and successively to various prominent points, drawing lines upon the paper to correspond to their direction. Then laying off according to the scale the length of the measured line, we proceed with the table to the other extremity of this line, and having fixed its position on the table, we observe from there the objects seen from the other end, drawing in like manner lines corresponding to their directions. The intersections of these last lines with those first drawn, are the positions on the map

corresponding to the several observed points. The roads, streams, and contour lines intervening between the points determined, are sketched in by the topographer.

For a limited extent of surface, the liability to error in this kind of work would not be very great, but for an extended area it is necessary to resort to a more accurate method for determining the positions of the several points and the distances between them. It is obvious that a linear measurement along the surface would not accomplish this object, since the inequalities of the ground, and the many obstacles which would be met with would greatly increase the chances of error.

To obviate this, we have recourse to a system of triangles, by means of which we measure in the air, above all obstacles, the distances between the points.

When the area to be surveyed is very extensive, such as that of a State or Territory, in addition to determining the distances between the several points, we have to determine the actual position of these points upon the surface of the earth, or in other words, their latitude and longitude. These last operations are termed Geodetic.

GEODOSY.

Geodosy is the science by which we determine the figure and dimensions of the earth, and the exact position of all points on its surface.

The first step to be taken in a Geodetic survey, is to make a general reconnaissance or examination of the country, for the purpose of determining the most elevated or most advantageous points, which could be used for trigonometrical purposes.

The next is the careful measurement of a base line, suitably located upon a plane as nearly level as possible, having previously selected certain elevated points in the vicinity, one or more of which might be seen from the extremities of this base line.

We then measure with a theodolite, the angles included between the base line and the lines drawn from the extremities to

the several visible points, which are called stations. From these observations we are enabled to determine the length of these lines, which in their turn serve as bases to determine the length of other lines. In this manner we cover the whole area to be surveyed with a net work of triangles.

Observations for the determination of latitude and longitude are made at both the extremities of the base line, and also at most of the principal points.

The triangles are made as large as the nature of the country, and the power of the instrument will admit, both on account of economy in time, labor and expense, as well as to avoid error, since the larger the triangles the less the chance of error. Within these large triangles we select other stations, which are connected with the first by observations.

The smaller triangles thus formed are called secondary, the former being designated as primary. Within the secondary, still another series is formed called tertiary, which last serve as bases for the work on the plane table sheets.

Various elements enter into the calculations of the primary triangles, such as spherical excess, observation, error, etc., the details of which it is not deemed necessary to enlarge upon.

MAPS.

Having indicated the nature of the operations in the field, the next step is to transfer this field work to paper, or in other words to construct a map.

If we could trace upon a sheet of paper the meridians of longitude, and parallels of latitude, precisely as they are represented upon a globe, we should have no difficulty in referring each locality to these conventional lines, and thus constructing a map which would be an exact representation of nature.

But the surface of the earth being spherical, we cannot represent it upon a plane surface, without altering to a greater or less extent the proportions of the territories, the distances between

the places, the sinuosities of the rivers, etc. We must therefore resort to some method by which these representations can be made, while distorting as little as possible, the actual distances.

To make a map of the earth we represent each hemisphere in perspective. That is to say, we suppose the eye to be situated at some arbitary, but fixed position in space, and that a transparent plane is interposed between the eye and the hemisphere. If we conceive every point of the hemisphere to emit a ray of light, each ray would pierce this transparent plane in a point, and supposing the plane to retain this image, we would have a representation of the hemisphere, as it appears to the eye.

When we wish to make a map of a more limited extent of country, such as a State or Territory, we resort to an arbitrary system of right lines or curves to represent the meridians and parallels; constructing a net work upon which we place each locality according to its latitude and longitude. This is called a projection. There are various methods of projections, all possessing a certain degree of merit. Of course those are the best which approximate nearest to an actual representation. The method of projection which has been selected, as offering the most advantages in constructing the map of New Jersey, is the one which has been generally applied to the topographical maps, formed on the Geodetic surveys of many of the European States. To construct a map on this projection, we assume first a central parallel. Along the parallel, a cone is conceived to be tangent to the sphere, and we develope the central meridian on that element of the cone which is tangent to it.

Then developing the cone on a tangent plane, we find the central parallel falling into a curve, with its centre at the vertex, and the meridian into a right line. Laying off upon the developed meridian certain elementary distances, we draw through the points of division a series of arcs concentric with the developed parallel. The spaces between these arcs are evidently the developement of the zones between the parallels.

All these zones have in devolopement the same relation to each other, and the same length and width as they had on the spheroidal surface; the total area remaining unchanged.

Each meridian is so traced as to cut each parallel in the same point, in which it intersected it on the sphere. For areas of no very great extent the intersections are almost rectangular. The distances along the parallels are strictly correct, but distances along the meridians increase in proportion to the diminution of the cosine of the angle between the radius of the parallel, and a tangent to the meridian at the point where they intersect.

Each quadrilateral of projection preserves its spheriodal area, but its two diagonals become unequal, one increasing and the other diminishing, as we go from the centre to the corners of the map, the inequality being greatest at the east and west polar corners. The application of this method of projection to the construction of the map of the State, will be shown under the head of "Drawing."

In this brief outline of the principles upon which the survey is conducted, it is seen that the basis of operations is a general preliminary examination or reconnaissance of the whole State.

GENERAL RECONNAISSANCE.

Geographical Position and Extent.

The State of New Jersey lies between the parallels of 41 deg. 20 min., and 38 deg. 55 min. 50 sec. north latitude, and the meridians 73 deg. 54 min. 10 sec. and 75 deg. 34 min. 15 sec. longitude west from Greenwich. It occupies a peninsulated position with respect to the State of New York, which bounds it on the north, and from which it is separated by an artificial line running from the point where the parallel of 41 deg. intersects the Hudson River, to the point where the parallel of 41 deg. 20 min. intersects the Delaware River. This line is 48.5 miles in length. On the east the boundary line follows the Hudson river until it empties into the Bay of New York; thence it fol-

lows the strait which separates the State from Staten Island. The remainder of the eastern and south-eastern boundaries is formed by the Atlantic Ocean. The Delaware river forms the western and south-western boundary, seperating the State from Pennsylvania and Delaware. The total area contained is 7,750.93 square miles, being 4,960,595.20 acres, of which 1,767,991 acres are improved, leaving a residue of 3,192,604.20 acres unimproved land. The total value of the farm land is $120,237,511.

PHYSICAL FEATURES.

The elevated portions of any country form the key to its topography. The hills and mountain ranges furnish the sources, while they direct the courses of the rivulets and the rivers. By their disintegration they form the plains and furnish the soil of the valleys. By them the climate is in a great measure determined; and around their summits are nursed the clouds which bring the early and the latter rain. Hence it is, that when we would indicate the topography of a country we go first to its mountain ranges; although it is difficult to form a just conception of these great features when the description is limited by political divisions.

The most elevated, most distinctly marked, and most clearly developed mountain range in the State of New Jersey, is that called the Blue Mountains. Entering near the initial point of the northwestern boundary, on a base of three miles, and with an elevation of 1,400 feet, it takes a southwesterly direction, widening at the base, but maintaining the same average height, for a distance of 15 miles, when it becomes six miles in width. Then it begins to contract, and finally leaves the State at the Delaware Water Gap, with a width of but half a mile, and an elevation of 1,500 feet, having an entire length in the State of 25 miles, with a remarkable uniformity of elevation. The greatest depression is at Culver's Gap, where it is 800 feet in height. Between the foot of the western slope and the

Delaware river, is a valley averaging one mile in width. This valley is drained by the Flatkill, a stream which runs through nearly its entire length in a southerly direction, parallel to the Delaware, being fed on its way by an infinite number of smaller streams, which serve the double purpose of irrigation and drainage. East of the Blue Mountni, and contiguous to it, lies a broad and fertile valley, known as the Kittating valley, extending from the northern boundary in a southwesterly direction, parallel to the Blue Mountains, through the counties of Sussex and Warren, to the Delaware river, being about forty miles long and ten broad. It is broken, through its entire extent, by a succession of low rounded hills, which have a culminating point about fifteen miles from the northern boundary —causing the rainage of the southern portion to flow towards the Delaware, and that of the northern portion to flow in the opposite direction, through the State of New York, towards the Hudson.

The Paulins Kill drains the southern part, and the Walkill the northern. Both streams are fed by numerous small lakes and ponds, whose basins are high up in the mountain ranges which bound the valley. So extensive are these reservoirs, that for a considerable portion of the year the Wallkill overflows its banks, inundating the country which it ought to drain, and destroying the fertility of a large tract of country which would otherwise be smiling fields. The next marked topographical feature is the continuation of the Highlands of New York, which enter the State in the same general direction as the Blue Mountains, but without its continuous aspect. This range consists of a succession of parallel ridges, intersected by occasional narrow valleys, but all following the same general direction northeast by southwest. These ridges have different names in the different localities where their features appear more marked, yet they form a connected whole, whose base in the northern boundary is about twenty-five miles, gradually narrowing to the south, being about ten miles wide at the Delaware.

Within this range lie several large and beautiful lakes, and numerous small ponds. A thousand mountain streams have here their source, and uniting, form the principal rivers of the State.

The Raritan river rises here, and running in an easterly direction, gathering on its way from every hill its spring, and from every valley its drainage, it becomes at New Brunswick, fifteen miles from its mouth, a navigable river, and empties through a broad arm into the Atlantic ocean, having a total length of seventy-two miles.

The Passaic, seventy miles in length, rises here, and empties into Newark Bay, and thence into the Atlantic.

The Hackensack, forty miles in length, rises in the same range, although not in the State, emptying also into Newark Bay.

Besides these rivers, the numerous valleys which intervene between the ridges have all their drainage streams.

The Pequest, thirty miles in length, emptying into the Delaware, is a bold and rapid stream, affords abundance of water-power, and drains a fine valley.

The Musconetcong river is the outlet of Lake Hopatcong, which lies almost in the heart of the range. This lake is five and a half miles in length, and one and a half miles wide, containing nearly four and a half square miles of water, or about two thousand five hundred acres. It is now used as the feeder of the Morris Canal. The Musconetcong is forty miles in length, flowing in nearly a straight line in a southwest direction, through a deep and narrow valley. It has a large volume of water, and gives motion to a number of mills.

There are many other streams, draining smaller valleys between these ridges, generally branches of either the Raritan or Passaic.

Next to the chain of the Highlands, on the east lies a broad, slightly elevated and slightly undulating plateau, extending

over a large area, from the northern boundary to the Delaware, with an average width of twenty miles. The surface of this plateau is broken by a succession of narrow, abrupt ridges, which traverse it in a northeasterly and southwesterly direction. These ridges are so much higher than the surrounding country, as to afford fine points for observation and for trigonometrical stations. This plateau terminates in the southeast at the narrowest part of the State, on a line drawn from Amboy to Trenton, which line was at one time the shore of the sea. The remainder of the State below this line, and as far as Cape May, is almost a level plane. A transverse line of gentle elevation divides it sufficiently to cause a portion of its drainage to flow towards the Delaware, and another towards the Atlantic. The streams, of which there are a great number flowing in both directions from the summit level, have so slight a descent, and a current so sluggish, that in many places they may be almost regarded as a succession of swamps and ponds. The whole character of the country forms a striking contrast to the other portions of the State.

The latter came into existence amid the convulsive throes of nature which followed the early affinity of matter. The former, born of the ocean at a calmer period, seems, in its gentle uniformity, to reflect the eternal lullaby of the waves which ushered it into existence. More than once, since it arose from the water, this area has sought its native element; rising for a period to court the smiles of the sun, then dipping with its green vesture into the sea, seeming indications on the bosom of the earth of the pulsations of the great heart within it.

Nearly the whole of this extensive area is covered with a dense forest, rendering it a matter of impossibility to obtain a view of the surrounding country, even from the highest of the few hills which appear upon the surface.

There is one marked feature connected with the topography of this portion of the State. From near Cape May, the extreme southern point, there extends along the coast, for a distance of

one hundred miles, a sheet of water separated from the sea by a narrow strip of sand-beach, and communicating with it by openings across this beach at several different points along its length. The action of the winds and waves are constantly producing changes, both with regard to the beach itself and the openings through it; still the interior channel remains constantly open, and is used as a means of commercial communication between the towns upon the coast. Certain observations connected with the importance and improvement of this channel, but which do not, from their nature, pertain to a general reconnaissance, will be given in a future report.

This rapid glance at the physical features of the State, while it indicates their marked peculiarity, will serve at the same time as a guide in following the detailed operations of the Geodetic and Topographical parties.

ARTIFICIAL FEATURES.

Internal Improvements.

The position occupied by the State of New Jersey, with reference to the large and thickly populated States of New York and Pennsylvania, the peculiar advantages derived from its shores being watered by two of the finest rivers in the United States, and especially its position with reference to the harbor of New York, all combined to call the early attention of its citizens to the value and necessity of artificial means of communication.

Accordingly, we see projected and carried out, a system of railways and canals, which, while they have added materially to the wealth of the State, have also conferred great benefit upon the adjoining States, and upon the country at large. It has been the policy of the State, instead of attempting these internal improvements by the State Government, thereby opening an avenue by which its finances might become embarrassed, and the credit of the State endangered, to confer such privileges upon incorporated companies as to induce private enterprise, with private

capital, to undertake these public works. The result is, that the State has a revenue without taxation, and a treasury free from debt, while railroads and canals intersect the country in every direction.

The following statement exhibits the general nature and extent of the internal improvements of the State. It is not as complete as would be desirable; still there are, it is presumed, no material errors.

CANALS.

Delaware and Raritan Canal.

This important work commences at New Brunswick, the head of navigation of Raritan river, and extends to Bordentown, where it enters the Delaware river, being forty-three miles in length. It is seventy-five feet wide at the surface, forty-seven feet wide at the bottom, and nine feet deep.

There are seven locks at each end, each two hundred and twenty feet long and twenty-four feet wide, admitting the transit of boats of five hundred tons burden. The canal is supplied with water by a feeder extending twenty-two miles above Trenton. It connects with the Delaware division of the Pennsylvania Canal, and is at present the principal avenue through which New York is supplied with coal. It also commands a large amount of freight between New York and Philadelphia, and is navigated by regular lines of propellers moving between the two cities.

The annual transportation of coal is over one million tons; of grain over one million bushels; and about two hundred thousand tons of general merchandise.

Cost of the canal - - - - -	$3,707,915 90
Receipts for the year 1854 - - -	474,740 89
Expenses " " - - -	171,753 98
Earnings " " - - -	303,186 41

The Morris Canal.

This canal extends, by a circuitous route, from the Hudson river at Jersey City to the Delaware river at Philipsburg, opposite Easton, where it connects with the Lehigh Canal of Pennsylvania. The boats are carried over the chain of the Highlands by means of a series of locks and inclined planes. This canal was projected for the purpose of opening a means of communication between the coal fields of Pennsylvania and the large mineral deposits of the northern portion of the State, and between the latter and the New York market. It is one hundred and one miles and three quarters in length, thirty-two feet wide at the top, twenty-two feet at the bottom, and four feet deep.

The locks are seventy-five feet in length, and nine feet wide. Their limited capacity prevent the canal from transporting a large amount of coal, but it has been the means of opening to market a vast amount of mineral wealth, and may be regarded as a source of great vitality to the northern counties of the State; while its conception and execution bear evidence of a skill and perseverance which has not been without its effect upon the State at large.

RAILROADS.

Camden and Amboy Railroad.

This was the first railroad built in the State. It extends from Amboy, on Raritan Bay, to Camden, on the Delaware, opposite Philadelphia. It connects with New York by steamboat, and with Philadelphia by a ferry. It is ninety miles in length, and has a branch road from Camden to New Brunswick, where it meets the New Jersey Railroad. Upon it, in connection with the New Jersey Railroad, is thrown not only all the travel between the two largest cities in the Union, but between the two great divisions of the country.

As might be expected from such relations, it commands an immense amount of passenger-traffic, and ranks among the

most successful and productive works of the kind. It is much more important as a route of travel than commerce, since the Delaware and Raritan Canal, which has the same general direction and connections is a better medium for heavy transportation.

Cost of the road - - - - -	$4,763,184 58
Receipts for the year 1854 - - -	1,682,486 23
Expenses " " " - - -	1,130,092 10
Earnings " " " - - -	552,457 13

New Jersey Railroad.

The New Jersey Railroad extends from Jersey City to New Brunswick, thirty-one miles, passing through the large manufacturing towns of Newark and Rahway. At Elizabeth City it connects with the New Jersey Central Railroad, and thence with the great coal basin of Pennsylvania. This road is of great local importance, but its chief traffic is in connection with the Camden and Amboy branch road from New Brunswick to Camden, by which it is extended to Philadelphia, making a total length of eighty-seven miles.

Cost of the road - - - - -	$3,239,592 51
Receipts for the year 1854 - - -	824,032 93
Expenses " " " - - -	383,585 21
Nett earnings " " - - -	440,447 72

Central Railroad of New Jersey.

The Central Railroad of New Jersey ranks high in prospective importance, while its local value is now very great. It extends from Elizabeth Port, on Newark Bay, to Phillipsburg, on the Delaware, opposite Easton, being sixty-three miles in length, passing through the most fertile portions of the counties of Essex, Somerset, Hunterdon and Warren. At Elizabeth City it connects with steamboat to New York. At New Hampton it connects with the Warren Railroad, extending to the Water Gap, where it meets the Delaware, Lackawanna and Western

Railroad of Pennsylvania. At Easton it forms a connection with the Lehigh Valley Railroad, and thence with the Dauphin and Susquehanna, and the Catawissa Railroads; all extending into the heart of the great coal basin of Pennsylvania. This road has now a double track, and the company has contracted to deliver in New York the coming year five hundred thousand tons of coal. It is contemplated to extend this road to Jersey City, crossing Newark Bay at its entrance.

Cost of the road - - - - -	$2,805,683 71
Receipts for the year 1854 - - -	378,145 33
Expenses " " " - - -	197,349 43
Nett earnings " " - - -	180,795 90

Morris and Essex Railroad.

This is an important road, having characteristics similar to the Central road. It extends from Newark to Hackettstown, a distance of fifty-three miles, with a proposed extension to the Water Gap.

Its cars run over the rails of the New Jersey Railroad from Newark to New York. From Hackettstown it is intended to extend the work to a point on the Delaware river, opposite the Water Gap, where it will connect with roads leading into the Lackawanna valley, thus affording another outlet from the great coal basin to the seat of commerce. The local traffic of this road is rapidly increasing, which fact may be stated for all roads in the State. When the extension of this road is completed, it will be one of the most important coal roads in the country, and it will also have a powerful effect upon the developement of the rich mineral districts through which it passes.

Cost of the road - - - - -	$1,549,621 68
Receipts for the year 1854 - - -	233,595 64
Expenses " " " - - -	134,216 33
Nett earnings " " - - -	99,379 31

Belvidere Delaware Railroad.

This road extends from Trenton along the Delaware river to Belvidere, in the county of Warren. It is an important road as an auxiliary communication between Philadelphia and the north-eastern coal basin of Pennsylvania. At Lambertville it connects with the Flemington Railroad to Flemington, which is now used as a branch of this road. At Phillipsburg it intersects and connects with the Central Railroad.

The total length of the road, including the branch to Flemington, is seventy-five miles. At Trenton it connects with the Camden and Amboy, and the Philadelphia and Trenton Railroads. This road has not been long enough in operation to form a correct estimate of its work.

The cost of it has been upwards of $2,500,000.

Warren Railroad.

The Warren Railroad extends from the Delaware river, at the Water Gap, in the county of Warren, to the Central Railroad of New Jersey, near New Hampton, having a branch to Belvidere. It connects at the Delaware river with the Delaware, Lackawanna and Western Railroad, of Pennsylvania. The branch road connects with the Belvidere and Delaware Railroad at or near Belvidere. This road is not yet completed. When it is done, the Central road will have three connections with the coal basin.

A correct estimate cannot yet be formed of its costs or results.

Flemington Railroad.

The Flemington Railroad, from Lambertville to Flemington, in the county of Hunterdon, is twelve miles in length, and is an agricultural road, worked as a branch of the Belvidere Delaware Railroad.

Cost of the road - - - - - $211,281 63

Freehold and Jamesburg Railroad.

An agricultural road in the county of Monmouth. It extends from Freehold, the county town, to Jamesburg, where it connects with the Camden and Amboy road.

It is eleven miles in length, and cost $163,743 91.

Burlington and Mount Holly Railroad.

A branch of the Camden and Amboy road from Burlington to Mount Holly, in the county of Burlington.

It is six miles in length, and cost $163,763 91.

Sussex Mine Railroad.

This road extends from Newton to Waterloo, in the county of Sussex. It is twelve miles long, connecting with the Morris and Essex Railroad at Waterloo. It is an agricultural road, used principally for the transportation of iron; cost about $800,000.

Millstone and New Brunswick Railroad.

This is an agricultural road from Millstone to New Brunswick, in the county of Somerset, six and sixty-three hundredths miles in length, and cost $106,636 22.

Camden and Atlantic Railroad.

This is an agricultural road, extending from Camden, on the Delaware, to Atlantic City, on the Atlantic Ocean, passing through the central portion of the counties of Camden and Atlantic. This road depends for its success upon the cultivation and development of a large area of land hitherto a dense forest. The trees are gradually disappearing under the hands of the woodman, and a few years will work an entire change in the whole face of the country. It is also anticipated that this will form a connection with a new route for transportation, between New York and Philadelphia. Atlantic City, one of the termini of the road, is a place of resort in the summer season, where is found excellent sea bathing. The road is sixty miles in length, and cost $1,499,185 91.

Paterson and Hudson River Railroad,

From Paterson to Jersey City, is seventeen miles in length; cost $630,000, and is leased to the Erie Railroad Company.

Paterson and Ramapo Railroad,

From Paterson to Ramapo, near the State line, is the continuation of the Paterson and Hudson River Railroad. It is seventeen miles in length, cost $350,000, and is leased to the Erie Railroad Company.

New York and Erie Railroad.

This road having leased the two last mentioned roads, has increased the gauge, and run its passenger cars to Jersey City, instead of Piermont as heretofore.

Besides the railroads which have been enumerated, there are a large number which have been projected in different parts of the State, some of which will undoubtedly be completed within a short period. There are but three which from their importance call for a special notice in the present report.

Delaware and Hudson River Railroad.

This road is projected by the Pennsylvania Coal Company, who are the owners of a very large tract of land in the Pennsylvania Coal Basin. The coal from the mines has been and is now brought to market by the way of the Delaware and Hudson Canal, and being limited by the capacity of the canal, the company is able to bring to market neither the amount they are able to mine, nor an amount sufficient to supply the demand. A strong necessity to obtain some other avenue to market has thus been forced upon them. The mode by which they propose to transport their coal, while it is novel and interesting in its design, would in the event of its execution, be of very great value to the northern portion of the State.

It is well known, and more clearly shown in the topographical

description of the State, that while the territory of New Jersey is the shortest route to the seaboard from the coal basin, the value of distance is lost from the fact that almost insurmountable barriers obstruct a direct communication. The construction of the Morris Canal was an effort to obviate this difficulty, but for want of capacity it has not accomplished its object. On the other hand, the New York and Erie Railroad, and the Central Railroad of New Jersey, by going around these obstacles have sought to avoid the difficulty.

The plan proposed by the Pennsylvania Coal Company is what is called the Gravity road. It seeks to make the obstacles themselves useful while surmounting them, that is to say, by means of a series of inclined planes, with short ascents and long descents and stationary engines at the summit of each plane. The cars being raised up the short ascent by means of the engines, are suffered to descend the slope by force of gravity. The route proposed is to ascend to an elevated point on the Blue Mountains, at the Walpack Bend, from there alternately descending and ascending along the western slope, until it reaches Culver's Gap; from thence it descends into and crosses the Kittatinny valley, then ascending the Hamburg mountain to Snuffstown, it descends in one long plane to the Hudson River. It is seen that this route passes through the very heart of the great iron region of the State, and should the project be carried into successful execution, the hum of busy industry will replace the silence of these mountains and valleys.

The West Jersey Railroad.

In this project is embraced several different routes, having for their object the developement of the south-western portion of the State, or the area included principally within the limits of the counties of Camden, Gloucester, Salem, Cumberland and Cape May.

These counties are, from their position, off from the general line

of travel, and the market is reached solely by steamboat communication on the Delaware, requiring all the produce to be transported to the steamboat landings.

A railroad with a central location would be of great benefit, not only as a means of transportation for the present products, but also by increasing the facilities, to increase the products. The different routes which have been surveyed to this end are shown on the sketch.

Delaware and Raritan Bay Railroad.

This road is a project for materially shortening time and distance between the northern and southern sections of the Union. The eastern portions of the States of New Jersey, Delaware and Maryland, on account of the uniformly level nature of the surface, offer peculiar facilities for the construction of railroads. The obstacles to a connected line of road are the bays which intervene. It is proposed, by means of a regular connection between boats and cars, to form a direct line of connection between New York and Norfolk. The part of the line which lies in New Jersey is laid down on the map.

As far as this State is concerned, it must be of great benefit to it as a means of developing a large area of land now lying unproductive.

Camden, Pemberton and Freehold Railroad.

A company has been chartered for the purpose of constructing a railroad between the points indicated in the above title, and the surveys for location have been made. A glance at the accompanying sketch will show at once that it passes through a district yet unvisited by any line of railroad. In addition to this, it is a new district, with its soil still covered to a great extent with a primitive forest. As a means of agricultural developement, the road possesses striking features, and although the present population along the line proposed is not very great, yet there is no doubt that its completion would produce an entire

change in the whole face of the country, and open for cultivation an extensive area, which as it now is, might as well be in the far west.

It is proposed in the final report to give a full and illustrated description of every work of public interest, that may be at that time completed within the limits of the State. At the present date the total length of completed railway in the State is five hundred and four miles, costing about twenty millions of dollars.

FIELD WORK.

Organization of parties.

There is no duty connected with the survey more difficult or delicate than the organization of the different parties. Their duties are of such a nature as to require the greatest skill, combined with the highest integrity. As the parties are broken up at the close of the season, we are deprived of the advantages which would be derived from their increased proficiency. Much depends, therefore, upon judgment in selecting proper persons for the different positions, and there is always a chance of being deceived, until their character and capacity have been tested in the field. Fortunately, but few instances have occurred in which the persons were not what they professed to be, and these were not such as to result in any material detriment to the survey.

Both the triangulation and topographical parties are composed permanently of a chief, a first and a second assistant. When circumstances require it, one or more temporary assistants are employed. The chief has the immediate charge of the party, and upon him depends its good conduct, and the accuracy of the work. He keeps a daily journal of everything connected with the survey which transpires in his party, and transmits a weekly abstract of the same to the office. The first assistant gives to the chief such assistance as he may require in the details of the work. He also keeps a record of all the information he may be able to obtain concerning the character of the

soil and mineral deposits; communicating semi-monthly all of the items connected with the geology of the district in which the party may be located, which he may deem of sufficient importance. These reports are of material assistance to the Geologist in going over the ground. The duties of the second assistant are more manual than otherwise.

As soon as each plane table sheet is completed, it is turned into the office, accompanied with a manual containing the numbers corresponding to the house on the sheet, and the names of the occupants of each house, the amount of cultivated and uncultivated land in each farm, the depth of every well, and the soil passed through in digging it, the three crops which have the highest average, and if any what mill or mineral property is being worked or developed by any person whose name is in the manual.

This furnishes a complete index to the present condition of every section of the State, upon which reliable estimates and calculations may be based.

TRIANGULATION.

In the examination of the physical features of the State we have seen that while in the northern division we have two distinct mountain ranges, besides many isolated points of elevation, the southern division presents scarcely a single prominent point, and therefore that a triangulation of the latter can only be accomplished by erecting stations at the necessary points. It follows that the triangulation would be first pushed towards the north, more especially since the Coast Survey, in prosecuting its hydrography, has completed a secondary triangulation of the Atlantic coast, and the Delaware river as far as Trenton, thus giving the plane-table parties in the southern counties a sufficient number of geographical points to enable them to prosecute their work without chance of error.

As was stated in the report of last year, the coast of the Uni-

ted States, for the purpose of the geodetic survey, has been divided into eleven sections, in each of which a base line from five to ten miles in length has been measured. The coast of New Jersey is included in the second of these sections, the base of which is on Fire Island, which adjoins the coast of Long Island. The primary triangulation extends across the State, from Amboy to Trenton, and down the Delaware river. The necessity for measuring a base-line in the State is thus obviated, since a side of this primary triangulation can be assumed as our base of operations. The side which has been selected, is the line forming Mount Rose station, in the county of Mercer, with Springfield station in the county of Essex. The length of the line is twenty-nine miles and forty-three hundredths. The latitude of Mount Rose is 40 deg. 22 min., and its longitude 74 deg. 43 min. The latitude of Springfield is 40 deg. 41 min., and its longitude 74 deg. 21 min. This line occupies a central position, and is very favorably situated for the continuation of the triangulation, especially towards the north. The many prominent points there found have afforded us a choice of positions, and we have thus been able to establish such stations as to give us well conditioned triangles, which we have extended to the Delaware river, and the northern boundary, one station being in the State of New York. The number of stations occupied is 25; the number of observations made is 460.

The whole net-work, as far as has been completed, including that of the Coast Survey, is shown in the accompanying sketch. The heights of all the stations occupied have been determined by means of a barometer. A table of all the geographical positions which have been determined in the State is annexed, for reference in local surveys. The triangulation party has been under the direction of Mr. Fuellhart, who has exhibited throughout a commendable activity.

The provisions of the act authorizing the survey require that each county shall be completed separately, consequently the operations of each plane table party have been limited by the county divisions.

Operations have been carried on during the season in nine counties, to wit: Sussex, Warren, Morris, Hudson, Monmouth, Salem, Cumberland, Cape May, and Atlantic. Of these, Sussex and Cape May are completed—while Salem, Morris, Monmouth, and Warren are nearly so—with material progress in the others. The following detailed account exhibits the progress of the work in each county:

County of Sussex.

The field-work of a large portion of this county was completed during the latter portion of the past year.

This being the first work done in the survey, and done, in a great measure, with the assistance of young men, who, to say the least, were unpracticed in their duties, it is natural to suppose that a certain degree of revision was necessary to insure the accuracy of their work. This revision has been made, and the topography of the county completed, and it is presumed that no material errors will be found in it.

The plane table party assigned to duty in this county took the field on the 3d day of April, under the charge of Mr. Charles A. Heering; Mr. T. B. Brooks, first assistant. Until the 1st of June their operations were greatly impeded, by the extreme quantity of rain which fell in the months of April and May; nevertheless the party, by their industry and strict attention to their duties, were enabled to complete the field-work of the county on the 1st of September. Mr. Heering was transferred, on the 1st of August, to the Morris County party, and his place taken by T. Benton Brooks, who applied himself so closely to his duties as to injure his health, and render it necessary for him to proceed

to the South. He anticipates joining, in the spring, with renewed health.

The map of the whole county of Sussex is now drawn, and submitted with the report.

County of Morris.

A plane table party took the field in this county on the 1st day of May, under the direction of Mr. Fuellhart; Mr. R. W. Patterson, first assistant.

From that time until the 1st of August, when he was relieved from the charge of the party by Mr. Heering, Mr. Fuellhart turned into the office two plane table sheets, each containing one hundred square miles, exhibiting a large amount of labor. Mr. Heering remained in charge of the party until the first of November, and completed about one hundred and thirty square miles. On the above date the field-work of Morris County was suspended for the season, and Mr. Heering was transferred to the charge of a party in Cumberland County. The party will resume the field in this county early in the spring, and the map will be completed by midsummer.

County of Salem.

While the absence of mountains, and even of hills, in the southern portion of the State, relieves the topographer from a great deal of labor in respect to contour lines, nevertheless these very features of the surface is an impediment in the way of rapid progress. The want of elevated points compels him to increase the number of his stations, and the forests intercept the view entirely. The streams, also, in a flat country, especially near the sea, are very tortuous, and as a general thing are too deep to be forded—and there being but few bridges, a great deal of time is lost in simply going from one point to another.

These remarks apply to all the work done in the lower counties, more particularly, however, to the county of Salem. The party assigned to do duty in this county, was placed in the field

on the twentieth of April, and withdrawn on the twenty-fourth of October. About one hundred and twenty-five square miles of topography was completed, which, with the topography accomplished by the Coast Survey, and drawn on the map of Delaware Bay, leaves a comparatively small portion of the county remaining. The whole county will be completed early in the ensuing season.

County of Monmouth.

The party took the field in this county on the 1st day of May, under the charge of Mr. G. Bechtle. As this county borders upon New York Harbor, a considerable portion of its topography has been completed, and engraved upon the large maps of the harbor, printed by the Coast Survey.

The party commenced operations on a line drawn through Red Bank and Shrewsbury, and worked into the interior. About one hundred and forty-five square miles of topography was completed, in addition to that of the Coast Survey, making a total of about two hundred and fifty square miles. The extreme accuracy of detail measurement maintained by the chief of this party, and which is not essential or practicable in a map of this nature, caused a slower progress than would otherwise have been accomplished. Mr. Bechtle has exhibited, throughout the season, a praiseworthy degree of industry and conscientiousness. Mr. I. M. Bunnell was the first assistant of this party during the greater part of the season.

County of Hudson.

A party was placed in the field in this country on the twenty-sixth of April, but in consequence of the fact that the commissioners on harbor encroachments, appointed by the Governor of the State of New York, having decided to make a re-survey of the harbor and adjoining lands, which survey was commenced, under the direction of the Superintendent of the Coast Survey, it was deemed advisable to suspend operations in this county, and

withdraw the party until such re-survey was completed, when we shall have the benefit of it.

County of Warren.

On being withdrawn from the county of Hudson, the plane table party, under the charge of Mr. G. G. Friedlein, as chief, with Mr. Charles E. Baldwin as first assistant, was transferred to the county of Warren. They remained in the field until the 6th of November. During this time the most difficult part of the topography of the county was completed, embracing the northern portion, from the county of Morris to the Delaware River, and north of the line from Hackettstown to the Delaware Water Gap. The party worked with due diligence, and the plane table sheets, as well as the field-notes, exhibit great care and accuracy of detail.

County of Cape May.

The party took the field in this county on the 20th of August, Mr. V. E. Koerber, chief of the party, and Mr. O. Dietz first assistant. The very peculiar nature of this county being almost a perfect level, and covered for the most part with a dense growth of trees, through which an infinite number of roads ramify themselves in every direction, rendered the work here a matter of patient industry and tedious labor. No elevated points present themselves upon which the topographer can establish himself, and determine his position. He must needs follow every road with a chain and compass, oftentimes having his way intersected with interminable swamps, and for miles and miles no human habitation meet his eye. The survey of the county is now completed, and the party is engaged in the county of Atlantic.

County of Cuumberland.

This party, under the charge of Mr. Charles A. Heering, with Mr. I. M. Bonnell as first assistant, was transferred to this county from Morris. On the first of November they established

themselves upon points of the secondary triangulation of the Coast Survey, in the vicinity of Greenwich, and are working in the direction of the interior. One plane table sheet is about completed. Should the weather prove favorable, they will be able to turn into the office the greater portion of the county by spring.

County of Atlantic.

The party operating in this county is under the direction of Mr. V. E. Koerber, and is the same party which completed the survey of the county of Cape May.

Their first plane table sheet in this county is just commenced, yet judging from the fidelity and skill displayed by the party thus far, we may look for their completion of the survey of the county in a very reasonable time.

TRUE MERIDIAN LINES.

By an amendment to the bill making an appropriation for the continuation of the survey, it was made incumbent on the persons in charge of the work to establish several lines in different portions of the State, indicating the direction of the true meridian, for the purpose of furnishing to local surveyors a means of ascertaining the variation of the compass in different localities at different times.

Newark, Trenton, and Camden, were designated as the points for locating these lines. It is the intention, however, to establish the meridian, if possible, in every county. Reconnaissance for selecting favorable positions has been made at Paterson, Trenton, and a preliminary line located in Newark; also some of the monuments have been prepared. Owing, however, to the non-receipt of an instrument to be used for the purpose, which it was expected would be loaned by the Coast Survey, the lines have not yet been located. Early in the ensuing season, when the demand for their instruments will not be so great in the Coast Survey office, it is anticipated that all these lines will be determined.

OFFICE WORK.

Drawing.

In the drawing division, work was commenced simultaneously with the field operations. In a proper organization of the work, the projection of the geodetic net work forms the basis, not only for the drawing of the maps, but also for the plane table sheets. This will be first referred to.

It has been stated that the conic projection has been selected for the map of the State, as being that one which afforded advantages over all others. This method requiring a central meridian, and a central parallel, we have selected Princeton as the central point. Having drawn the principal meridian and parallel, and constructed the other meridians and parallels according to known principles, which have been referred to, we divide each quadrilateral of projection into smaller quadrilaterals, corresponding to the size of the plane table sheets; these are referable by the co-ordinates of their corners to the central point. And by having on each sheet at least three trigonometrical stations, we have no difficulty in locating the precise position of the sheet in the field. In the desire to accomplish the topography of certain district for the use of the Geologist, the system has not been strictly adhered to, but the necessity for a deviation from it no longer exists.

In addition to plotting the geodetic net, calculating and plotting the triangulation, the draughtsmen have completed the maps of the counties of Sussex and Cape May, besides furnishing tracings of nearly all of the plane table sheets to the geologists, and supplying enlarged copies of the Coast Survey work to the different plane table parties.

The small scale upon which the last year's field work in the county of Sussex was done, rendered the drawing of the map of the county very difficult. The patience and industry which has been shown in its execution are worthy of praise.

Mr. J. H. Pieper, principal draughtsman, has been unremitting in the discharge of his duties, giving to the work a great deal of time and attention not called for by the terms of his employment.

Engraving.

Deeming it proper that the character of every part of the work should be in keeping, the work of engraving on copper was commenced in the month of August, with the map of the county of Sussex, on account of the drawing of that county being completed. The map will be in four plates, two of which are nearly finished. The execution of the work thus far has fully met the expectations that were formed, both as to beauty of finish and economy, for it is seen that if one-half the prices usually paid for the most ordinary maps is fixed for these maps, the cost of engraving and printing will be defrayed. The plates can be electrotyped at the Coast Survey office in Washington, if it is deemed advisable, or the maps may be printed from lithographic transfer plates.

CONCLUSION.

In concluding the report, a brief reference should be made to one or two facts, which have been mentioned for the purpose of pointing out more distinctly their bearing upon the general welfare of the State.

It appears that out of 4,960,595 acres of land included within the limits of the State, there are 3,192,604 acres entirely uncultivated. Yet there are in New Jersey no deserts, nor dismal swamps, where the labor of man would be exhausted in vain efforts to redeem nature for his wants. No charge has ever been made that the people of New Jersey are deficient in energy, in intelligence, or in skill. Still there must be some reason why so much tillable land should remain undisturbed by the plough of the husbandman, while millions of non-producers almost within sight stand ready to produce every grain that is offered to

them. The reason why it is so is sufficiently obvious, but why it should remain so is not so plain.

Why it is so, arises from the fact that the early settlers of every country establish themselves along the rivers and smaller streams, where a little toil is remunerated by an abundant harvest. This soil, however, becomes in time exhausted by constant tillage, and the farmer finds that he cannot, from his own resources, renew it, and that he must purchase foreign fertilizers to maintain the productions of his farm. His profits become diminished in consequence, and he or his sons begin to think of seeking a new sphere where their labor will meet with a better reward. Now, we would ask if those lands which are *not* on the rivers and streams, and which are *not* as productive *at first*, as the more recent alluvials, cannot be made as productive, with a less amount of fertilizing matter, and at a less cost, than is now required to fructify the exhausted lands? This is a great question, which, in view of the proximity of the market, in view of the increasing demand, and in view of the great amount of scientific skill which can now be brought to the aid of agriculture, should engage the earnest attention of the farmers of the State.

Another point which should be referred to, is the obvious connection between the internal improvements and physical features. One glance is sufficient to show that to the mineral deposits of the State and Pennsylvania, are due, with one exception, all of the main lines of canal and railway within the State. Extensive as they are, may it not be possible that they are but a foreshadowing of what will be? Is there not space enough, and material enough, for a Birmingham on Morris Plains, or for a Manchester in the Kittatinny Valley?

The immense amount of water power now almost wasted on a thousand insignificant saw mills, in the northern part of the State, needs only enterprise to make its value known and felt. Nothing but enterprise has built up, upon the island of Manhattan, a splendid city of over half a million of souls, while the Jer-

ney shore, having more commercial facilities, is a comparative suburb.

It is the object of this survey to develop the resources of the State in such a manner, that every citizen may be as familiar with every portion, as he is with his own immediate neighborhood, and that the people of the State, from a comprehensive sense of the value of these resources may be incited to more vigorous effort.

It is not alone from an advantageous geographical position—a favorable topographical configuration—a genial climate—a fertile soil—or mineral riches—that a State derives its wealth and power; they come from the active energy, intelligence and industry of its people, seeking, under salutary laws, and free institutions, a higher state of development. While ignorance and indolence would in effect reduce the State to comparative poverty, well directed industry adds new beauty to its fair face, and increases the wealth of its prosperous people.

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State Topographical Engineer.

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REPORT

ON THE

GEOLOGICAL DEPARTMENT.

SOUTHERN DIVISION OF THE STATE.

To Dr. Wm. Kitchell, *Superintendent of the Geological Survey of the State of New Jersey:*

Sir:

I herewith submit the second Annual Report on the geological survey of the Southern Division of the State.

Respectfully yours,

GEO. H. COOK,

Assistant Geologist.

New Brunswick, Dec. 29, 1855.

REPORT

ON THE GEOLOGY OF THE SOUTHERN DIVISION.

The field-work in the geological survey of the southern division of New Jersey, has been chiefly confined to the counties of Monmouth, Salem, and Cape May. Examinations of a somewhat general character have also been made in the counties of Cumberland, Gloucester, Camden, Burlington, Ocean, and Middlesex.

It will be convenient to arrange the material of the report under the following heads:

1. Recapitulation of last year's report.
2. Further examinations in the work commenced last year.
3. Examination of other geological formations.
4. Chemical examinations, and practical suggestions on them.
5. Progress of the survey in different counties.

Cedar swamps.

Gravel bricks.

1. *Recapitulation of last year's work.*

In the report of last year it was stated that the southern division of New Jersey, as divided for the purposes of the geological survey, had, for its northern boundary, a line running in a southwesterly direction from Staten Island Sound, near Elizabeth Port, to the Delaware river a little below Trenton—following generally the southeastern margin of the red sandstone and shale which is so conspicuous a feature of the central part of the State. All of the State south of this line is included in the southern division.

The whole of this district is remarkable for its low and generally level surface, and for the entire lack of rock formations. Its geological structure, however, is very regular and uniform. With some exceptions, which will be mentioned hereafter, it is made up of successive strata, which stretch across the State from the northeast towards the southwest, and descend beneath the surface towards the southeast; so that, as we pass from the north, or division line, across the State in a southeasterly direction, the strata are crossed in succession, the lowest first, then the next above, and so on in order to the highest. In this way the light colored clays, including the fire and potter's clays, are first crossed; then the black and chocolate colored astringent clays; then the several beds of greensand marl, with intermediate beds of sand; and lastly, the more recent beds of shell-marl, sand, clay, and gravel, which make up the southeastern part of the State.

Of the clays which are next the red sandstone, no description was attempted, except it was remarked that the upper portions of the dark clays contained more or less green-sand—the latter being found in spots and irregular streaks in the clay. The stratum containing the greensand marl was principally described from observations made upon it in the eastern part of Monmouth County, though it was known to be pretty regularly developed entirely across the State to its southwestern extremity, near Salem, in Salem County. Three distinct beds of greensand were mentioned. The first of these includes the marls which are found north of the North or Neversink river, Swimming river, and Yellow brook, and on the headwaters of South river. The second includes those found on both sides of South or Shrewsbury river, and of Hockhockson brook, and on the headwaters of some branches of Yellow brook and Manasquan river. The third includes the marls of Deal, Poplar, Shark river, and Squankum. These beds all incline towards the southeast. The first of them passes under a thick bed of reddish or yellowish

sand, which inclines the same way with the marl, and in its turn passes under the second bed of marl. Between the second and third marl beds there is a heavy bed of sand, in color and appearance much like beach sand, except that it has greensand grains scattered all through it.

The fossils in the several beds are mostly distinct, and characteristic ones are to be found in each. The first contains great numbers of large oyster shells; (*Gryphea convexa* and *Exogyra costata*;) also the *Belemnites Americanus*, *Terebratula sayii*, and *Ostrea falcata*. The second is characterized by the *Terebratula harlani*, *Gryphea convexa* and *G. vomer*, and by numerous corals. The third has many fossils not found in the other beds; some of them have not yet been described.

The material which gives name and character to these beds is in little grains about like gunpowder in size, some shade of green in color, soft, and when crushed on the nail or on paper it always leaves a green streak. This is what is commonly known as greensand, but in the district where it is found or used in New Jersey it is called marl. It is mixed with more or less of sand, clay, and lime, the latter both in the form of fine powder and in shells.

The first bed, which is perhaps thirty feet thick, presents the appearance of several distinct layers; the bottom very sandy, with some marl grains; next above this is a layer of nearly black and almost pure marl grains; then a layer of marl, containing a great many shells and much carbonate of lime in fine powder; this layer is usually some shade of blue or gray; then another much like the second; and lastly, one in which marl grains and thin, flaky shells, are quite abundant at the lower part, but as we get higher a black clay takes the place of the shells and marl grains, and at the top it is only a micaceous black clay. The marl from this bed, after exposure in heaps, is of an ash or slate color.

The bed of sand overlying this is much colored with oxide of

iron, and where it is sufficiently firm, is found to be almost full of the impressions of shells. The upper part of it is mixed with, and colored by, a greenish earth or clay.

The second marl-bed was described as in three layers; first, one of marl grains, almost free from earth or shells; then one in which the marl is mixed with numerous soft and white shells; and highest, one in which the marl grains are almost entirely wanting, and broken shells, corals, &c., with a little sand, make up the mass. In some places, this last layer is hard enough for a rock, and is burned into lime. The marl of this bed, when exposed, is a yellowish green. The sand between the second and third beds has usually been confounded with beach or surface sand, which it closely resembles.

The third bed of marl is also in three distinct layers: the lower one of green marl and clay; the second one almost entirely of a sandy, drab-colored clay; and the third of marl grains largely mixed with drab-clay, the whole having a bluish-green color. Marl from this bed, on exposure, is of a green color, intermediate to the first and second.

A few analyses of marls from the different beds were presented, in which phosphoric acid was shown to be a constituent of all the good marls; and it was also shown that those which have the best reputation as fertilizers possess the largest per centage of that substance.

Nothing was said of the formations above the marl.

2. *Further examinations in the work commenced last year.*

During the past season, the marl formation has been traced up to a considerably greater extent than before. The lowest bed which was traced from the sea shore west to the road between Freehold and Englishtown, in Monmouth County, has been followed up across the remaining part of Monmouth to Burlington County; and it has been traced entirely across Gloucester and Salem Counties to near the Delaware river. The second bed,

which had been examined only as far as Blue Ball, in Monmouth County, has been traced entirely across the counties of Monmouth, Ocean, Burlington, Camden, Gloucester, and Salem. The third has been traced from Squankum, across Ocean and Burlington counties, and to Clementon in Camden County, beyond which, after careful inquiry and examination, no trace of it has been found.

In describing the geographical position of the marl beds, advantage may be taken of their direction, or *strike*, and of their inclination, or *dip*, to define with more closeness their exact location. To ascertain the strike, two places in the same bed, and on the same level are taken, and the bearing of the straight line between them ascertained. At Red Bank, in Monmouth County, the top of the lowest bed of marl is at tide level; in the same bed, near Marshallville, in Salem county, the top of the marl is but a few feet above the same level; and at St. Georges, in Delaware, the top of the bed is also at tide level; the straight line running through these points bears S. 56 W., or N. 56 E. The bottom of the second bed is only two or three feet below tide at the north end of the bridge over Parker's Creek, near Shrewsbury, in Monmouth County; the bottom of the same bed is just above tide level, on the bank of Salem creek, at Mr. Geo. Abbott's, a mile from Salem; the line joining these is also S. 56 W. The top of the same bed is opened near Long Branch village, in Monmouth County, and at what I judge to be about the same level, in the pits of George Ward, near Swedes bridge, in Mannington township, Salem County; and the direction of line S. 56 W. In the third or highest bed, there are not yet sufficient observations made to determine its strike, but enough to make it probable, that it has the same as the others. It is to be presumed that slight variations from this direction will be observed in some instances, but generally the strike of the marl stratum may be taken at S. 56 deg. W.

The dip is ascertained by drawing lines down the slope, or

descent of the beds, at right angles to the strike, that is in a direction S. 34 deg. E., and finding the angle of inclination between these lines and horizontal ones; or else by finding how many feet these lines rise or fall to the mile. The heights of many of the marl pits in a part of Monmouth County, have been ascertained by levelling, and from these it is calculated that the dip of the first bed is not far from thirty feet to the mile. That of the second and third beds cannot yet be given with equal exactness, but it is nearly the same as the first.

At Winslow, in Camden County, an Artesian well was bored for the Winslow Glass Works, and the Hon. A. K. Hay has kindly furnished the following account of the strata passed through:

12	feet,	stiff sandy loam.
7	"	clay.
93	"	quicksand.
35	"	stiff black clay.
28	"	quicksand.
27	"	black sand.
44	"	brown sand.
33	"	black clay.
20	"	dark green marl and shells.
17	"	light greensand and marl.
316	"	whole depth.

Winslow is about twelve miles southeast of Clementon, where the nearest marl pits are opened. The elevation of Winslow or Clementon is not ascertained. Longacoming, lying between them, is 180 feet above tide, and is higher than either of the other places. The fact is interesting, as proving the descent of the marl towards the southeast for a great distance, and if the two places should be upon the same level, it would show that the rate of descent is nearly the same as in the beds, when near the surface.

As many measurements of the marl stratum as possible have been taken and recorded. There is only one section at present known in the State, where one of the marl beds can be seen in its full thickness—and that is in the Highlands on the shore of Sandy Hook bay, where the first bed can be seen with the bed of clay below, and that of sand above. At most places where marl is dug, the pits are in fields, or banks of streams, and the upper part of the marl has been changed by the action of air and moisture, so that is not recognised; and at the bottom, water, caving in of pits, or other causes, hinder the workmen so that they rarely observe the exact termination of the marl. This makes it difficult to find out the thickness of the layer. And in the pits where the ground is wet, they are generally dug and filled up the same day, so that it is difficult to get a description of the material passed through, even where the depth is ascertained.

Thickness of the first bed.

At the Highlands, on the shore of Sandy Hook bay, the following section was measured; reddish-yellow, or ferruginous sand, of great thickness, lying over the marl:

9 feet of black, micaceous and astringent clay.

5 feet of black clay as above, with some thin and flaky shells.

25 " of marl, greensand; the upper part, for three or four feet, mixed with the clay over it, the rest almost free from clay, and consisting of marl grains, fine carbonate of lime, shells and a little sand.

3 " sand and small gravel, with marl grains and shells.

42 " total thickness.

Chocolate colored, or almost black clay, in thin layers, with seams of sand between, underlies the last mentioned layer.

At the North American Phalanx pits, on Hop brook, in Atlantic township, Monmouth County, the black clay is seen overly-

ing the marl, but not in its full thickness. The following series of specimens, obtained at the different depths mentioned, were presented by Mr. Charles Sears, President of the Association:

At 6 feet, the sample is an average, and is a micaceous clay, dark colored, and containing some thin and tender shells, and a few marl grains.
" 9 " specimen similar to the preceding, but with more marl.
" 12 " clay, with large per centage of marl grains.
" 15 " marl without clay, but with some fine carbonate of lime; bluish gray color.
" 18 " same as at 15 feet, but of a little darker color.
" 21 " same as last specimen.
" 24 " lighter colored marl than the preceding, and containing a large per centage of fine carbonate of lime.
" 28 " same as the last specimen.
" 30 " similar to the last, but a shade darker.
" 32 " more of a bottle green color, and the marl grains finer.
" 34 " same as preceding.
" 36 " same.
" 38 " same.

From 21 feet down, the specimens were obtained by boring; the boring terminated in marl.

At the pits of Wm. Hartshorne, a mile and a quarter north of Freehold, the following measurements were obtained:

Near his pits the overlying black clay was found to be 11 feet. At the pits, commencing at the surface—

3 feet dark micaceous clay, containing shells.
4 " clay, with shells and numerous marl grains.
6 " marl, grey, and containing shells and fine carbonate of lime.

15½ " marl, like the last, though varying slightly in color, some parts being darker and others lighter.

The last distance was bored, and ended in sand, for which if we add 8 feet, we have a total of 42½ feet.

A great number of other cuttings in the marl have been examined and measured, but in almost all cases the upper part of the marl is wanting, having been denuded or worn away, at some period since its deposition. In those cases where the upper part of the bed is plainly seen, it has not been penetrated to a sufficient depth to find out its thickness. At Cream Ridge, in Monmouth County, the marl is dug from seven to twelve feet deep. At Sculltown, in Salem County, the marl is dug from eight to fourteen feet; and near Marshallville, in the same county, it is dug from twelve to sixteen feet, and then stopped by water. At Batten's mill, near Swedesboro', in Gloucester County, the diggings are from eight to twelve feet.

The thickness of the ferruginous sand bed which overlies the first marl bed, as determined by levelling and making due allowance, for the descent of the marl, is from one hundred to one hundred and ten feet.

The second marl bed is not exposed in its full thickness at any one place, and it can only be determined by measuring the separate layers and taking their sum. The layer of green marl is opened—

10 feet at Shepherd's, near Blue Ball, Monmouth County.
20 " at Imlay's, on Crosswicks creek, below New Egypt, Ocean County.
13 " at Gaskill's, on the Rancocus, below Pemberton, Burlington County.
16 " Heritage's, near Union Cross Roads, Camden County.
14 " at Ware's, near Barnsboro, in Gloucester County.
14 " at Dickson's, near Woodstown, in Salem County.
18 " at D. Petit's, in Mannington, Salem County.

Which gives an average of fifteen feet—a number undoubtedly too small.

The layer of marl and shells is nearly
10 feet thick at Mr. Horner's, near New Egypt.
5 " at Bill's, near Blue Ball.
6 " at Heritage's, near Union Cross Roads.
4 " at Stratton's near Mullica Hill.
3 " at D. Petit's, Mannington.

Which gives an average of five and three-eighths feet. The layer is variable.

The layer of broken shells, corals, &c., which is opened in a great many places, does not anywhere show its full thickness. It has been penetrated without finding bottom,

14 feet at Mr. Pitcher's, near Long Branch ;

20 " or more at Mr. D. Petit's, Mannington, which gives an average of seventeen feet.

The sum of these would give thirty-seven and three-eighths feet for the thickness of the bed—but it will probably be found too small.

From the levelling in Monmouth County, I estimate the *sand* between the second and third marl beds at about forty feet.

The *third bed* must be measured in the layers, like the second, and it will be convenient to take those in Monmouth County repeatedly, as it is only there that the three layers are found.

The green marl layer is
16 feet at Mr. Gardner's, in Deal.
18 " at J. Shafto's, Shark river.
18 " at Capt. Weeks', Squankum.
Average seventeen and one-third feet.

The ash colored layer is
10 feet at Van Benthuysen's Poplar.
10 " at G. Shafto's, Shark River.
10 " at Forman's, Lower Squankum.
Average 10 feet.

The blue marl layer is
14 feet at Abner Allen's, Deal.

8 " at Amos White's, Poplar.
9 " at Petit's, Shark River.
7 " at Forman's, Lower Squankum.

Average 9½ feet.

The sum of these is thirty-seven and five-sixths feet.

The green marl of the third bed is—

5—10 feet at New Egypt in Ocean County, and at Poke Hill in Burlington County.
12—12 " Pemberton.
12—14 " Vincentown.
6—8 " Christopher's Mill, near Marlton.
6—7 " Clementon.

Average 8 1-5—10 1-5 feet.

The strike, dip, and thickness, of these marl beds being known, may now be used in describing their geographical position. A reference to the map of New Jersey will be useful in studying out the following description. All the pits opened in the first bed lie to the northwest of the straight line mentioned on page 59, as being drawn from Red Bank to near Salem—their distance from it depending on their height above tide. In the examinations thus far made, the distance is about one mile for every thirty feet above that level. All the pits in the second bed, with a few exceptions, lie to the southeast of the above-mentioned line; and they are all to the northwest of the line mentioned on page 59, as being drawn from Long Branch to Swede's Bridge. The exceptions spoken of are those marl pits which have been opened high up in the Highlands, and in Sugar Loaf Hill in Monmouth County, in Mount Holly, Burlington County, and at a few other very elevated points. In the third bed, the openings in the central part of the State are on high ground, and are a little to the northwest of the last mentioned line; in Monmouth they are to the southeast of it.

The openings in the marl are principally made in valleys, and in the banks of streams, on account of the streams having washed

away the surface material of sand, clay, loam, and gravel, and left the marls more exposed than they are on the ridges. The accompanying sketch will convey an idea of the localities in which marl is very commonly dug. The drawing was made from the pits of the Hon. N. Stratton, near Mullica Hill, Gloucester County. A branch of Raccoon creek runs down the valley, and the sketch was taken looking towards the northwest, and down the stream. Piles of marl dug out and ready for removal, are seen near the banks, on both sides of the valley. Most of the marl is found below the level of the flat ground, but the pits from which it is dug are not seen, being filled up with top-dirt which is removed in uncovering other pits. The pile of stones seen in front is of the upper, calcareous, or yellow limestone layer of the second bed, and is found overlying the marl at this part of the valley. The lines of stratification seen in the bank, appear to be due to some action of air and moisture on the surface material, and have no relation to the marl. In the valley farthest down, the green marl is found immediately under the surface earth; nearer, a considerable layer of shells and greensand is passed through before coming to the pure greensand; and opposite to the point from which the view was taken, there is a thick layer of limestone and limesand above the layer of shells and greensand. The relative position of the several layers of the second marl bed are thus well shown, also the descent of the marl towards the southeast. As the marl is worked farther back from the stream, the banks become higher, but the marl continues on the same level, which lends support to the opinion that the bed is continuous under the high grounds, between the valleys. But it is also very common to strike the marl at a considerable depth in wells and other excavations, at a distance from the streams.

In describing the first bed of marl, in last year's report, two layers of black marl were mentioned, as of common occurrence. Further examination has shown that these layers are not uni-

MARL PITS. NEAR MULLICA HILL. GLOUCESTER CO

form, and that they are owing to a chemical change which is now going on. These black layers contain no shells, scarcely any lime, and they are in many cases acid in their properties, from the presence of sulphate of iron, (copperas,) or sulphate of alumina, (a kind of alum.) In a marl pit near Heading's Corners, Middletown, Monmouth County, the black marl is in perpendicular streaks—made evidently by the copperas from the surface soaking down through the bed. In these streaks no shells are seen, and there is no vegetation on the surface; while in the gray marl between, and adjoining them, the shells are of their natural appearance and composition, and white clover grows luxuriantly. A similar case was observed in Upper Freehold, Monmouth County, near Imlaystown. Sulphuret of iron (iron pyrites, or, as workmen call it, sulphur,) is common in the subsoil in many parts of the marl district, and the action of the air and moisture on this, with the clay of the soil, produces copperas and alum. Some of the black marls, when thrown out in heaps, become covered with a white efflorescence, showing that they contain sulphate of lime (plaster); others of them become covered with a yellowish white efflorescence, remain damp, even in dry weather, and have an inky taste, showing that they contain copperas.

The marl of this bed appears to be more sandy as we go towards the southwest. Specimens from Salem and Gloucester show to the eye a greater per centage of sand than those from the eastern part of Monmouth. In a letter to me in relation to the marls on the property of the North American phalanx, Mr. Chas. Sears says that in two different cases it has been mentioned to him, by men who have worked in the wet and muddy marl, that distinct streaks of phosphoric light have been observed on applying friction to their clothing or persons—and one of them says that he perceived the well known odor of friction matches. Each of the men related the circumstances without any knowledge of what the other had done.

In the bed of ferruginous sand, there is much more firmness in

its substance in the southwestern part of the State, and the traces of fossils are much more distinct in it. A very interesting collection of fossils from it has been made by Wm. Snowden, of Mullica Hill. For a number of miles, across Camden and Gloucester counties, the top of this bed is a layer of material almost like stone; it is from six inches to two feet in thickness, and consists of a mass of casts of shells cemented by oxide of iron. The most common fossil in this layer is the *Exogyra costata;* Belemnites are common and numerous; other forms are seen. Some of the fossils, particularly the Belemnites, are composed of phosphate of iron.

In many parts of this highly colored ferruginous bed, masses of light colored sand are seen, sometimes without any distinct separation from the surrounding material, and in other instances inclosed by a firm crust of oxide of iron—as if the agent which had colored the rest of the bed had failed to penetrate these masses. Streaks of the same light colored material are also seen in some places; Mr. Snowden showed me, in the bottom of Raccoon creek near Mullica Hill, one of this kind. It had the appearance of a light colored, sandy limestone; effervesced very slightly with acids; and the Belemnites in it were still unchanged, being composed of carbonate of lime.

The upper part of this bed contains some clay, and is the basis of an excellent soil.

In digging marl in the lower layer of the third bed, the bottom has usually been found to be a whitish earth—called *white marl* in Squankum and Shark river, and fullers' earth in New Egypt and all places farther southwest, where this marl is dug.

3. *Examination of other geological formations.*

A beginning has been made in the examination of the beds of clay which constitute a regular formation, extending across the State, and lying between the red sandstone and the greensand marl. In their development on the surface they occupy a belt of from ten to fourteen miles wide across the State, and in their ex-

tension down the Delaware to their termination in the upper part of Salem County, they are of variable width. Their strike is not accurately determined, but is between S. 45 deg. W. and S. 55 deg. W., a little more southerly than the marl. Their dip is to the southeast, and from the few observations it has been possible to make, it is thought the inclination is nearly the same as that of the marl.

Over much of this formation there is a thick bed of sand, gravel, and other drift material, which effectually hinders access to it. Their examination will be mostly confined to their outcrop on the Delaware and Raritan rivers—and during this season it has been confined to the latter of the two localities.

In this clay formation the lower part is made up of white and light colored clays, with intermediate beds of pure white sand, called fire-sand; over these lie the beds of darker colored clay, and the beds of clay containing streaks of greensand.

At Woodbridge, in Middlesex County, and near the red sandstone formation, great quantities of fire-clay are dug. At this place the surface material is usually red earth and stone, apparently drift from the red sandstone; under this is found, in some places, white and fine fire-sand, and in others black or dark colored clay. Under these is found the fire-clay—very uneven on its upper surface, as if it had been washed away in streaks or spots, after its deposition and before the sand and clay covered it.

In the bank of Thompson & Drake there is—

8—12 feet black clay next the surface.
5 " sandy fire-clay.
1—2 " fire-sand.
6—12 " best fire-clay.
5 " sandy fire-clay.
8 " white sand.

In the bank of Samuel Dally, after the earth is removed, there is—

2 feet sandy fire-clay.

1 1-2 " fire-sand.
10—12 " best fire-clay.
6 " fire sand.

In the bank of Peter Melick there is, after the top earth is removed—

6—13 feet of best fire-clay.
2—4 " fire-clay containing red stains.
2 " sandy fire-clay.
Sand.

In Hampton Cutter's bank, which is some distance south-east of the others, and on lower ground, there is—

3—4 feet of loamy earth next the surface.
7—8 " of fire-clay.
7—8 " of sandy fire-clay.

There are several other banks opened in Woodbridge, but these are sufficient to give the arrangements of the layers of clay.

To the south of Woodbridge, and on much higher ground than the clay bed, there is found on Isaac Flood's land a bed of, apparently, decomposed granite; coarse angular grains of quartz, with decomposed felspar mixed through it, and numerous very small scales of mica. Still further south, and on lower ground, this bed is opened on lands of Mr. Demarest, Mr. J. D. Forbes, and Mr. Inslee. In these, the material is mostly finer than at Mr. Flood's, though some resembles his closely. It is of a bluish white color, sandy in consistency when drained, but pasty when worked up in water. It is a very fine micaceous sand, with some fire-clay intermixed, and streaks of clay passing through it. It is called kaolin by the people of the vicinity. Still further south, and on lower ground, this bed is worked by Mr. Hall and Mr. Watson, near Perth Amboy.

It is 2—3 feet thick at Mr. Flood's.
6—8 " (probably) at Mr. Demarest's.
10—12 " at Mr. Hall's.

The bed is underlaid by a dark colored but refractory clay.

These facts, it is believed, are sufficient to prove that the beds dip to the south, or southeast.

If we examine them in a direction from the northeast towards the southwest, they will be found to run nearly level. Following up this direction from Woodbridge, we see the clay in the old Woodbridge road, below Bonhamtown, and again on the side hill near the road to Compton's fire-sand banks; and on the southwest bank of the Raritan it is found on the land of Mr. Hobart, just below the mouth of Lawrence's brook. The sand which is found under the Woodbridge clay is coarse, angular, and crystalline; sand of the same quality is found on the lower upland, near the Raritan, below Bonhamtown, and it is also found near Milltown, three or four miles west of the Raritan.

The kaolin bed is cut in the streets of Perth Amboy, it is dug three-quarters of a mile back of Ellis' point, on Staten Island, where it is twenty-five feet thick, and on the southwest of the Raritan, it is dug by Mr. Flood on the Kearney property, by Coleman, Whitehead, and others at Burt's creek, by Mr. Bolton above French's landing, and by Mr. Whitehead on the hill at Washington. In the last two it is seven feet thick, and underlayed by black clay. On Staten Island, and also southwest of the Raritan, the kaolin is overlaid by fire-clay. The fire-clay is

20 feet thick in Kricher's bank, Staten Island.

10—17 feet on the Kearney property, near South Amboy.

12 feet at Coleman's, Burt's creek.

12—14 feet at Gordon & Co.'s, Burt's creek.

4—7 feet at Bolton's, near French's landing.

2—3 feet at Whitehead's, Washington.

A fire-clay is dug by Mr. Pharsan, on the hill west of South Amboy. It is dark colored, and does not appear to be connected with either of the preceding beds. Light colored and refractory clays are dug at several places in the interior of the State, and good fire-clay is found in the neighborhood of Bordentown.

A bed of potter's clay, which is much used in the making of stone ware, is opened on the shore at South Amboy, a mile and a half southeast of the railroad depot; and also at the head of Cheesequake's creek, three miles and a half farther southwest.

On Raritan bay, John H. Clark removes

11—25 feet of sand next the surface.
5—7 " of black clay.
9—17 " of blue stone-ware clay.
1—3 " of an ash colored sand, coal and pyrites.
8—13 " of stone-ware clay.

Morgan's clay-bank, adjoining Clark's, was worked near the shore last season, and the clay was thinner than the above, but when worked farther in the bank, is similar to Clark's.

At the head of Cheesequake's, Morgan's bank is

15—16 feet of sand.
7 feet of black clay.
10 feet of potter's stone-ware clay.

At the pits of N. Forman, there is

3—10 feet of sand.
10—15 " of black clay.
14 " of stone-ware clay.

At the Amboy Clay Co.'s bank, they dig about 18 feet of stone-ware clay.

In all these banks the clay is very variable in thickness, being uneven, both at the top and bottom.

These are the principal distinct layers of the fire and potter's clays that have been examined.

The interval between the Woodbridge and the South Amboy fire clays, is filled by layers of light colored clay and sand; some of these layers almost white; others darker colored, and containing much fossil wood and sulphuret of iron. The layers of sand make but a small portion of the whole. The clays are well exposed in the bank of the Raritan, at French's landing, where, as well as at Washington, they are largely used in making common brick.

The interval between the South Amboy fire and potter's clays, is also filled up by layers of clay and sand; the clay, as far as can be judged by the few exposures made, is darker colored than those above mentioned.

The black clay, which has been spoken of as overlying the fire and potter's clay, is quite unconformable to them, though it appears to descend and pass beneath the surface a little farther southeast, as observed on the shore of Raritan bay. It is remarkable for the large amount of sulphuret of iron it contains, and also for its fossil wood. The latter is found in several places, in sufficient quantity to be used for fuel.

This clay is less black, in its layers adjoining the marl, and contains occasional streaks and irregular spots of green sand; —so much that it is used for that substance in many places. It also contains numerous casts of shells and marine remains.

Fossils are not common in the light colored clays; fossil wood is found in some of the layers, in large quantity, and some very distinct impressions of net-veined leaves were examined in the clay at French's landing. In the potter's clay at South Amboy, Mr. Clark says they have followed up a single tree for ninety-three feet, and from a diameter of five feet, with which they commenced, to fourteen inches. He says that the workmen have in one part of their bank, found a considerable number of small shells.

In the potter's-clay banks, on the bay shore, the clay is frequently stained from the bottom upwards, of a peach blossom color. Such clay, though it can be used for some purposes, is not as valuable as good stone-ware clay.

The same kind of stain is frequently found in the bottom of the fire-clay beds.

It should be remarked, that no difference has been made in recording the depth of the fire clay, as to whether it is fire, alum, or paper clay. These are accidental differences, though important to the consumers. The best fire clays are also the

best alum clays—though clay containing a little sulphuret of iron can be used for making alum, and is unfit for fire-brick. The common fire clay is white, with a bluish tinge; in some places it has lost this color, and is white, with a very faint buff hue. The latter is used for making satin-faced paper hangings, and is called paper clay. It occurs very irregularly. The change of color is undoubtedly owing to iron, which is a protoxoid in the blue, becoming a peroxid in the white or buff. After burning one cannot be distinguished from the other.

In the formations above the marl, and lying to the southeast of it, some examinations have been made, and a number of localities have been visited, where shell marl and shell beds are excavated for manure. Among these shells, there are found in every bed some which are like those now living, and there are beds in which the shells are identical with those now growing in Delaware bay and the Atlantic Ocean, adjacent. In a geological classification, these beds must be considered as tertiary or recent formations.

The most extensive of the shell marl beds is that which is largely worked, at several places on the head waters of Stoe creek, and its branches in Salem and Cumberland counties. The most south-westerly of the workings in this bed, is that of Isaac W. Elwell, near Jericho, in Cumberland, and the most north-easterly are those on the Ellis Ayres estate, in Salem County, but near Shiloh, in Cumberland.

Mr. Elwell's marl is in a layer from eight to twelve feet thick, and covered by a bed of sand twenty feet thick. The marl is somewhat uneven on the bottom, and is much furrowed on the top. It is filled with shells, most of which are in a soft and decaying state. The color of the marl is yellow on the top, and blue towards the bottom; but the two colors are separated by a very irregular line, in some places higher, and in others lower. In the marl to the northeast, in the Cook neighborhood, and on the Davis property, the sand and marl are nearly the same as at El-

well's. At the pits of John J. Hummel, they first remove twenty feet or more of top sand, to uncover the marl. The surface of the latter is very uneven, rising in knobs, and then falling in depressions. The top of the marl is covered for a few inches by a layer of bright red earth; then, and more uniform, a layer of yellow earth, like ochre; then a layer of from six inches to two feet of dark lead-colored clay, containing no white shells, but numerous impressions; this layer is, in some parts of the pit, solid stone; underneath this is the marl, which is of a greenish lead-color, and from ten to fourteen feet thick, filled with shells, mostly in a crumbled state. This terminates in a layer of astringent clay, denominated soap-stone. The pits on the west branch of Stoe creek, and near the straight road to Salem, have a considerable layer of the hard stone, and the marl is astringent in some spots. The pits of Mrs. Ayres are not covered with so much sand, and the marl is of a more uniform blue, and harder than those in the pits farther down. The marl is full of soft shells, and like the rest, slakes to a finer powder when exposed to the air.

The fossils in these marls, both shells and bones, are very abundant, and promise an interesting study to the palæontologist.

There is another series of shell marl openings in Salem and Gloucester counties, which may be an extension of this bed, or possibly, from its geographical position, lower. It is exposed in the pits of Wm. Clawson, in Salem County, a mile and a half south of Woodstown, and a little east of the Alloway's town road. It is also seen on the farm of M. C. Jennings, in Gloucester County, about two miles south of Mullica Hill, and a little east of the Commissioners' road; and again in several places within two or three miles northeast of Mr. Jennings. It is variable in appearance, in some cases being light and sandy, and filled with fragments of white shells; in others much more clayey, without shells, and with a perceptible amount of sulphate of

iron. In mineral composition and appearance, the latter description applies to a clay formation, which is found through the valley of Alloways creek, on up to near Woodstown, and is again seen at other places along quite into Ocean County. I have a specimen taken from a well in this formation, in Upper Alloways creek, which contains impressions of shells.

In many places in the flat upland, not far from the creeks, or from the bay, or ocean shore, in digging wells or pits, beds of shells, identical with those now found in the neighboring waters, have been struck. Mr. Stewart, in Lower Alloways creek township, Salem County, near the shore, and just below the mouth of Alloways creek, says that in two or three wells which he has dug, he has found oyster shells at the depth of about twelve feet. In several wells near Fairton, Cumberland County, the same fact has been observed. On the east bank of Maurice river, a short distance above Port Elizabeth, on land of Jonathan Lore, there is a bluff bank of fifteen or twenty feet high. In this bank, at about seven feet above high water, there is a bed of oyster shells; the bed is solid, two or three feet thick, in blue mud, and the shells packed closely, just as in beds now under water. The mud covers them for two or three feet, and then there is sand to the top. Shell marl is also dug on the Manamusking, three-quarters of a mile from Port Elizabeth; the shells are imbedded in blue mud, and covered with two or three feet of sand. Farther down the river, at Leesburg, the same layer of blue mud and shells is found, from three to six feet under the surface sand. At Heislerville, still farther down Maurice river, the same species of shells are found, and occurring in the same manner. Again, in Cape May County, three or four miles south of Beesley's point, and a little west of the sea side road, on lands of Jonathan Godfrey, a similar deposit of blue mud and shells, covered by sand, is found. At Tuckahoe, in the same county, casts and impressions of the common clam are found in the gravel, a little south of the town. There

is no lime in these, but the forms are in gravel, cemented by oxide of iron. At the south part of the county, on land occupied by Downes Edmonds, Jr., it is common to find oyster and clam shells in the upland, one or two feet beneath the surface.

Of the deposits of sand, gravel, and clay, which cover so large a portion of the southern counties of the State, there are not yet facts enough collected to make any general deductions from. No distinct stratification of these materials has been found as yet. In the wells bored at Cape Island, to the depth of about one hundred feet, the materials passed through were similar to those on the surface. The gravel stones found on the beach, and in the banks, are of a singularly mixed character. The Cape May diamond is much sought after by strangers; it is probably a water-worn quartz crystal, and beautiful specimens are sometimes found. There are pebbles of quartz of every hue; agates are not uncommon; pebbles of limestone, and rolled limestone fossils are frequent.

At Dennisville, in Cape May County, the gravel is very coarse, many of the pebbles being from one to two inches in diameter. Boulders are first found here in coming up from the Cape. They are principally of a light colored sandstone, some very firm, and others friable. The marks of stratification are plain in them, and they are quite angular. Mr. Nixon, of Dennisville, showed me a boulder weighing forty or fifty pounds, flat, and oblong in form; one side of which was covered with very large quartz crystals. They were milky and much broken. Near Greenwich, in Cumberland, there is a spot of ground filled with stone like that mentioned as being found over the marl in Hummel's pits, near Shiloh. The most common boulders in Salem county are of a very cellular quartzose rock. They are usually not large, and very numerous in spots, but generally they are thinly scattered. In many places the sand and gravel is cemented with oxide of iron, and is firm enough to be quarried and used for building purposes. The fragments are commonly flat, and are called quoit-stones.

A fossil tooth was found in the gravel at Goshen, and was presented to the State collection by Mr. Jona. Ingham; and some beautiful specimens of petrified wood from the gravel near Bridgeton, were presented by Dr. Potter.

The skull of a mastodon was dug up in the meadow of John Ewens, near Pemberton, Burlington County, last spring. It was in a good state of preservation. Its length was two feet ten inches; and its breadth, in the widest part, was one foot ten inches. Other bones of the mastodon were found near the same locality several years since.

During the past season, while in the southern part of the State, my attention was frequently called to the rapid wearing away of the shores, and to the advance of the tide-waters on the land. Local causes were generally assigned for the increased height of the tides; but this and other phenomena were extended over so long a line of shore, that it was thought there must be some general cause for them; and this cause appears to be, the slow but continued settling or subsidence of the land.

At the mouth of Dennis creek, in Cape May County, and for several miles along the bay-shore, on each side of it, according to the local surveyors, the marsh wears away, on an average, about one rod in two years; and, from the early maps, it would appear to have been going on at that rate ever since the first settlement of the country. A map of Cape May, in the possession of Dr. Maurice Beesley, of Dennisville, and bearing the date of 1694, lays down Egg Island, the western point of Maurice River Cove, as containing 300 acres; at low water it now contains a half or three fourths of an acre, and at high-water it is entirely covered. All along the Delaware Bay and river where the marshes are banked in to keep off the tide, the banks or dykes are placed several rods from the water's edge, to allow for the wearing away of the marsh.

At Town Bank, which is the principal bold shore on the west side of Cape May, and where the first settlement was made as

early as 1691, the solid gravel bank, which is from twelve to eighteen feet high, wears away, according to the owner, Mr. Thos. Hughes, about one foot a year. The foundations of the houses first built were long since undermined, and the waters of the bay now occupy the spot where they originally stood. At Cape Island, on the Atlantic shore, the wear is equally rapid, a full mile having been worn in since the revolution, as I am informed by Mr. Ezekiel Stevens. During the war of that period a militia artillery company had its practicing ground here. Their gun was placed near a house which stood just outside the present shore line, and their target was set up three quarters of a mile east. This last point was at the outer edge of the cultivated ground, and there was a quarter of a mile of sand hills or *beaches* between that and the water's edge. The whole of this is now gone, and one of the boarding houses has been moved back twice, on account of the wearing away of the bank. The sand beaches on the Atlantic shore are drifting in every year. Dr. Leaming says that Ludlam's Beach, opposite his residence, has moved inward fully one hundred yards during the last twenty years; and that the salt marsh sods which formed west of the beach are now seen on the strand east of it.

That the tides rise higher upon the uplands than formerly, is the opinion of the oldest observers, upon the Atlantic and Bay shores, from Great Egg Harbor quite around to Salem creek. Their opinion is founded on the fact, that on the low uplands, or those going down to the salt marsh with a very gentle slope, the salt grass now grows where upland grass formerly grew; and where the land was in wood, narrow fringes of it next the marsh are frequently killed by the salt water, and marsh takes its place. Hon. Joshua Brick, of Port Elizabeth, estimates the amount of timbered land between Maurice river and West creek, in Cumberland County, which has been killed within the last fifty years, at one thousand acres. And the amount is proportionally great on all the low and wooded shores. Numerous

islands (spots of hard ground surrounded by salt marsh) which, within the memory of men now living, have been cultivated, and others which were in wood, have been entirely lost in the advancing marsh, and their location is only to be known by the shallowness of the mud which covers them.

In all the salt marshes on the sea shore of southern New Jersey, and also in the salt and fresh tide marshes on Delaware Bay and river, stumps of trees, of the common species of the country, are found with their roots still fast in the solid ground at the bottom of the marsh, and this at depths far below low water mark. A reference to localities for these is not necessary. The fact is known to every one living in the neighborhood of these marshes, and the evidence of it can be seen in the bottoms or in the banks of almost every ditch that is cut in them.

The time during which this settling has been going on cannot be estimated with any degree of accuracy. But some idea of it may be obtained by noticing the phenomena of the cedar swamps where buried timber is dug or *mined*. In these swamps, and in the salt marshes near them, underneath the standing trees, or under the stumps in the marsh, cedar logs are found buried—and these one under the other, in such numbers, and so sound, that they are valuable for timber. By sounding with an iron rod, these logs can be felt under the surface at all depths, from one to ten feet, and some have said for even more than that. At Dennisvisville a well was dug in the marsh eleven feet in depth. The mud near the surface was the common blue-mud of the marshes; at a small depth the peaty cedar swamp earth was reached, and in it cedar timber, logs, and stumps, were found for several feet, and near the bottom the sweet gum (*Liquidambar styracifolia*,) and the spoon-wood or magnolia (*Magnolia glauca*,) were found. The well reached hard bottom. The white cedar grows on peat, and its roots run near the surface, so that it might be supposed the mud had settled with them, were it not for the fact that, when cedar grows where the mud is shal-

low, so that its roots reach hard bottom, its wood is unfit for timber, the grain or fibres being so interlocked that it will not split freely. Such is found to be the case in the buried timber; the bottom layer, as it is called, is worthless. From this the inference is conclusive that the hard ground was above tide level when those trees grew. Large stumps are frequently found standing directly on other large logs, and with their roots growing all around them, and then other logs still under these, so that one soon becomes perplexed in trying to count back to the time when the lower ones were growing. Dr. Beesley, of Dennisville, some years since communicated to the newspapers an article on the age of the cedar swamps, which was copied by Mr. Lyell in his Travels in the United States, Second Visit, vol. 1, p. 84; in which Dr. B. says that he "counted 1080 rings of annual growth between the centre and outside of a large stump six feet in diameter, and under it lay a prostrate tree, which had fallen and been buried before the tree to which the stump belonged first sprouted. This lower trunk was five hundred years old, so that upward of fifteen centuries were thus determined, beyond the shadow of a doubt, as the age of one small portion of a bog, the depth of which is as yet unknown."

Mr. Thomas Shourds, of Hancock's Bridge, Salem County, informed me that the sluices in a meadow bank near his residence, on Alloways Creek, were fully three feet below low water mark—so low, indeed, that within thirty years he has seen them but twice. The bank was built about the year 1700. Sluices are usually made in marsh earth, but it is said they do not settle much. And, in this instance, there is good reason to believe they are properly placed for what the tide must have been when they were set. On the opposite bank of the creek from these sluices there is an oak stump standing, the roots of which are in the solid bottom, and the top of it is about the level of high tide. The top is square, as if cut off by an axe, and the longest time since it was cut can be little more than one hundred

and fifty years. And when alive it must have been not less than three feet higher than now, to be out of the way of the tide. Judge Brick, of Port Elizabeth, says the tides have advanced a foot within fifty years—which, it will be perceived, agrees with the evidence to be obtained from the stump. Many persons have been disposed to estimate the rate of subsidence higher than this —but, in general, the statements are rather from impressions than from any fixed marks to refer to. I am confident, however, that two feet in a hundred years, is not above the rate at which the shore is now sinking.

The change of comparative level of land and water, though not generally noticed, is by no means uncommon. Very full accounts of such changes have been collected, and published by Mr. Lyell, in his work on the Principles of Geology. He says that "recent observations have disclosed to us the wonderful fact, that not only the west coast of South America, but also other large areas, some of them seven thousand miles in circumference, such as Scandinavia, and certain archipelagoes in the Pacific, are slowly and insensibly rising; while other regions, such as Greenland, and parts of the Pacific and Indian oceans, in which atolls or circular coral islands abound, are as gradually sinking."

From some facts collected, it would appear that the change on our own shore, is not confined to southern New Jersey. In the salt marshes on the Raritan, between New Brunswick and Perth Amboy, buried wood and stumps are common. Some years since a canal was dug across the marsh, from Washington to French's landing, to cut off some of the bends in South river, and the Raritan. The marsh cut through was from one to four feet deep, with a sandy bottom. Hundreds of stumps of the common yellow pine of the country, were found with their roots still firm in the sand as they grew; and though most of them were removed, a few are still to be seen at low water. The general impression at Washington is that the tides are fuller now than formerly. The marshes at the mouths of the Passaic

and Hackensack are well known to contain great quantities of buried timber, and it is but a few years since they were covered with cedar trees. The same is true of the marshes on the shore of Long Island. Prof. Hitchcock, in his report on the Geology of Massachusetts, give accounts of buried wood, erect stumps and peat, being found in the sea, at or below low water mark, as at the harbor of Nantucket, at Holmes Hole, on Martha's Vineyard, and also near the southwest extremity of the same island. They are seen too on the north side of Cape Cod, also opposite Yarmouth, and in Provincetown bay. Mr. Lyell, in his second visit to the United States, mentions a submerged forest "at Hampton, on the way from Boston to Portsmouth," also one near Portsmouth, N. H., "now submerged at low water, containing the roots and upright stools of the white cedar, showing that an ancient forest must once have extended farther seaward." In his First Visit to North America, vol. 2, p. 148, he mentions a submerged forest somewhat similar near Fort Cumberland, in Nova Scotia. In the same work, vol. 1, p. 181, in speaking of the coast of Georgia, he says, "I even suspect that this coast is now sinking down at a slow and insensible rate, for the sea is encroaching and gaining at many points on the fresh water marshes. Thus at Beauly, I found upright stumps of trees of the pine, cedar and ilex, covered with live oysters and barnacles, and exposed at low tides; the deposit in which they were buried having been recently washed away from around them by the waves." He records other observations in relation to the submerged trees at the mouth of Cooper river, near Charleston, and of the Altamaha, in Georgia. He quotes Bartram, the botanist, who wrote in 1792, as saying, "It seems evident even to demonstration, that those salt marshes adjoining the coast of the main, and the reedy and grassy islands in the rivers, which are now overflowed at every tide, were formerly high swamps of firm land, affording forests of cypress, tupelo, magnolia grandiflora, oak, ash, sweet bay, and other timber trees, the same as

are now growing on the river swamps, whose surface is two feet or more above the spring tides that flow at this day. And it is plainly to be seen by every planter along the coast of Carolina, Georgia and Florida, to the Mississippi, when they bank in these grassy tide marshes for cultivation, that they cannot sink their drains above three or four feet below the surface, before they come to strata of cypress stumps, and other trees, close together as they now grow in the swamps."

From the deposits of shells of recent species which were mentioned on page 76 as being found above the present high tide mark, it may be inferred that, at a period not very remote, our New Jersey shores were considerably lower than at present. This inference is corroborated by the appearance of the ridges of drift sand near Cape May. They are well shown on the right of the road from the steamboat landing to Cape Island. At about a quarter of a mile from the landing the innermost sand-ridge or beach is seen. This ridge is parallel to the present bay-shore, and lies upon the gravel which is the fast-land of the Cape. Between this and the bay-shore there are several parallel ridges of drift sand, in which the sand extends down at least to the water-level. It appears as if, at some former time, the waters of the bay had washed the gravel bank which now underlies the innermost sand ridge; and afterwards, as the waters receded, the sand from the strand was blown up, and lodged on this bank; and as the waters receded still farther from the original bank, other and parallel ridges of sand had formed in succession. The ridges have been formed long since, and have reared a heavy growth of black oak timber. They have ceased to advance, and are now wearing away with the advance of the water upon the land.

The indications, then, are that at some comparatively recent period, the ground has been several feet lower than it is now; that it has since been elevated to a height several feet above that at which it now is; and that it is now, and has been for a long time past, sinking slowly.

This gradual elevation and subsequent depression may have given to our coast its peculiarities. For almost the whole length of New Jersey, the main land is separated from the ocean by a strip of salt marsh, in some places several miles wide. On the outer edge of this marsh, next the sea, is a row of long, narrow sand islands, or *beaches*.

In many places where the waves wash against the head bank, the material is continually being worn away, and deposited as a sand-bar, or shoal, at some distance from the shore, and parallel to it, leaving comparatively deep water next the land. If we suppose this to have occurred during the former depression of the land, a series of shoals would have formed parallel to the coast. When a rising of the land took place, these shoals would be raised above the surface of the water, and become the basis of our present *beaches*; shrubs and trees would soon grow on them, to protect their surface, and to catch the sand which would drift up from the strand. The lower ground back would finally be elevated above the water, and would be covered by vegetation, shrubs, and trees; until a subsequent depression of the surface should again carry them below the tide-level, when they would become salt marshes—filling up with mud as the advancing tides would bring it in, and thus keeping their surface at high-water mark.

Sufficient evidence has not yet been collected to demonstrate this theory, but there is enough to render it highly probable.

4. *Chemical examinations, and some practical suggestions on them.*

The following analyses of marl, from different parts of the State, are presented, as good samples of this most valuable fertilizer:

1. *Analysis of a marl from Squankum, Monmouth Co.*

Water - - - - - - -	10.600
Silica - - - - - - -	51.162

Protoxid of iron	16.200
Alumina	6.100
Potash and soda	4.274
Lime	3.478
Magnesia	2.037
Phosphoric acid	4.540
Sulphuric acid	0.429
	98.820

This specimen was from the pits of Hance Herbert, and was taken from near the middle of the layer. It is a beautiful green marl, free from shells, and containing but very little sand. The marl grains are very small. It is very slightly acid in its reaction.

The specimen was dried by exposure to the open air—and it, as well as the following ones, was as dry as it could be made without artificial heat. Traces of manganese and of chlorine are to be found in all the marls, and a little carbonic acid is almost always present.

2. *Analysis of a marl from near Pemberton, Burlington Co.*

Water	10.410
Silica	55.930
Protoxid of iron and alumina	22.855
Potash	5.800
Lime	1.640
Magnesia	1.013
Phosphoric acid	1.680
Sulphuric acid	0.957
	100.285

This marl is from the pits of Joshua Forsyth, about three miles northeast of Pemberton. It is a dark green marl, without any shells, and is not acid. The specimen was taken from a heap.

3. *Analysis of a marl from Clementon, Camden Co.*

Water	10.640
Silica	56.200
Protoxid of iron	14.930
Alumina	6.000
Potash	5.375
Lime	1.985
Magnesia	1.615
Phosphoric acid	2.640
Sulphuric acid	0.439
	99.824

This marl is from the pit of Geo. Adams, in Clementon. It is dark green in color, and almost pure marl grains. It is not acid. The specimen was taken from a heap.

4. *Analysis of a marl from near Freehold, Monmouth Co.*

Water	9.800
Silica	54.110
Protoxid of iron and alumina	21.700
Potash and soda	6.985
Lime	0.482
Magnesia	3.789
Phosphoric acid	1.036
Sulphuric acid	1.437
	99.339

This specimen was taken from the pit of J. Shepherd, about a mile southwest of Blue Ball. It was taken from near the middle of the pit. It is almost pure marl grains, and is of a rich olive green color. It is decidedly acid.

5. *Analysis of a marl from New Egypt, Ocean Co.*

Water	12.050
Silica	49.768

Protoxid of iron and alumina	22.927
Potash and soda	5.784
Lime	2.563
Magnesia	2.795
Phosphoric acid	1.582
Sulphuric acid	2.267
	99.736

This marl was taken from the pit of Samuel Horner, near New Egypt. The specimen was from near the top of the green marl. It contains a few reddish colored shells, but the greatest portion is made up of clean greensand marl. It is not acid.

6. *Analysis of a marl from Pemberton, Burlington County.*

Water	9,600
Silica	49.340
Protoxid of iron and alumina	25.841
Potash and soda	6.920
Lime	1.217
Magnesia	4.210
Phosphoric acid	2.395
Sulphuric acid	0.133
	99.156

This marl is from the pit of S. R. Gaskill, on the north branch of the Rancocus, below Pemberton. It is from near the middle of the pit, and is a fine colored, clean greensand. It is not acid.

7. *Analysis of a marl from Blackwoodtown, Camden County.*

Water	11.000
Silica	49.940
Protoxid of iron and alumina	22.968
Potash and soda	6.306
Lime	2.367

Magnesia	2.714
Phosphoric acid	3.660
Sulphuric acid	0.625
	99.580

This specimen was taken from the pit of Mr. Marshall, at Blackwoodtown; about midway between the top and bottom of the green marl. It is free from shells, and is not acid. Small crystals of sulphate of lime (plaster) are scattered through it.

Analysis of a marl from Mullica Hill, Gloucester County.

Water	10.260
Silica	46.660
Protoxid of iron and alumina	24.921
Potash and soda	6.818
Lime	2.865
Magnesia	3.089
Phosphoric acid	3.599
Sulphuric acid	0.982
	99.194

This marl was taken from the pit of N. Stratton, about a mile east of Mullica Hill. It is a good specimen of the green-sand marl. It is not acid.

Analysis of a marl from Woodstown, Salem County.

Water	8.840
Silica	49.780
Protoxid of iron	19.800
Alumina	8.040
Potash and soda	6.815
Lime	1.048
Magnesia	1.812
Phosphoric acid	2.651
Sulphuric acid	0.112
	98.848

This specimen was from the pit of Richmond Dickson, near Woodstown, and was taken from a wagon. The marl grains are coarse, clean, and of a yellowish shade of green. It was probably taken from near the bottom of the green layer, and is scarcely an average of the marl in the bed.

Analysis of a marl from Marlboro, Monmouth County.

Water	12.200
Silica	38.700
Protoxid of iron and alumina	27.690
Potash and soda	4.467
Carbonate of lime	13.910
Magnesia	1.213
Phosphoric acid	1.140
Sulphuric acid	0.809
	99.629

This specimen was taken the pit of W. H. Conover, at Marlboro, and is a good sample of his best grey marl. It is made up of green grains, largely mixed with carbonate of lime, and a light colored clay. It is not acid—but efferverces rapidly when any strong acid is poured on it.

Analysis of a marl from Shelltown, Burlington County.

Water	5.700
Silica	67.260
Protoxid of iron	10.267
Alumina	4.360
Potash and soda	5.161
Lime	0.622
Magnesia	1.943
Phosphoric acid	0.178
Sulphuric acid	3.420
	98.911

This specimen was taken from a pit of Mr. Howard, near the bridge over Crosswick's creek, at Shelltown.

The marl is fine grained, dark green in color, and is irregularly mixed in the dark chocolate colored clay. It is acid in its properties, and when used with caution, is highly fertilizing in its action.

Of the marls whose analyses are given, those marked 1, 2, and 3, are from the third or highest bed; those marked 4, 5, 6, 7, 8, and 9, are from the second or middle bed; that marked 10 is from the first or lowest bed, and that marked 11 is from the clay which underlies the marl.

Analysis of a limestone from Salem County.

Water	0.500
Carbonate of lime	69.610
Magnesia	1.815
Peroxid of iron	2.810
Alumina	0.910
Silica	23.310
Phosphoric acid	0.039
Sulphuric acid	0.064
	99.058

This limestone was taken from the farm of Samuel Allen, in Mannington township, and is thought to be a fair sample of the limestone which is found in the calcareous layer of the second marl bed.

Analysis of a limesand, or marl, from Salem County.

Water	0.750
Carbonate of lime	84.730
Magnesia	1.404
Peroxid of iron	3.260
Alumina	0.860
Silica	8.110
Phosphoric acid	0.206
Sulphuric acid	0.230
	99.550

This specimen was taken from the pits of John Fowler, near Swede's bridge, in Mannington township, and is a sample of the loose variety of the upper part of the calcareous layer of the second marl bed.*

The value of these marls is best seen in the rich and highly cultivated district, which has been improved—almost made by their use; but it may be interesting to examine the causes of their great value in agriculture; and to compare them with other fertilizers. For example: the potash alone may be taken at an average as 5 per cent. of the whole weight of the marl; a bushel when dry, weighs eighty pounds, and in the proportion mentioned, would contain four pounds of potash,—this is nearly as much as there is in a bushel of unleached wood ashes. Or the phosphoric acid, the average of which is not less than two per cent. of the whole, and in many of the marls it is considerably above that, may be compared with superphosphate of lime. According to the analysis of several specimens of superphosphate, by S. W. Johnson, published in the Country Gentleman, vol. 1, p. 131, its average amount of phosphoric acid is 17 3-8 per cent., or from four to nine times as much as the marl, a difference by no means as great as between the prices of the two articles. Besides these constituents, the lime, the sulphuric acid, the oxide of iron, the soluble silica, and the magnesia, are all useful. It is probable that the great value of the marl is to be found in the fact, that it contains nearly all the substances necessary to make up the ash of our common cultivated plants. The following table, containing the amount and the composition

*The preceding analyses have been made under my direction, principally by Mr. Julius Kock, a competent chemist, a student of the Universities of Giessen and Marburg. The usual methods were adopted for the analysis of silicates soluble in acids. The alkalies were separated from the magnesia by acetate of baryta. The phosphoric acid was separated by molybdate of ammonia. There appears to be a small amount of organic matter in all the marls, but no attempt has yet been made to ascertain its composition.

of the ash, in different crops, grown on an acre of ground, is inserted for the purpose of comparison. It is from Boussingault's Rural Economy, p. 366 of the American edition:

TABLE.

CROP.	Dry crop.	Ashes, per cent.	Quantity of ashes per acre.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Lime.	Magnesia.	Potash and soda.	Silica.	Oxide of iron, Alumina, &c.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Potatoes . . .	2828	4.0	113	13	8.0	3	2	6	58	6	17
Potato tops . .	5042	6.0	303	33	7.0	4	7	5	135	39	16
Wheat. . . .	1052	2.4	25	12	0.3	. .	0.8	4	7	0.4	. .
Wheat straw .	2558	7.0	179	5	1.5	1	15	9	17	121	1¾
Oats	975	4.0	39	6	0.4	0.2	12	3	5	21	0.6
Oat straw . .	1176	5.1	60	1½	2.5	3	5	15	17	24	1
Clover. . . .	3693	7.7	284	18	7.0	7	70	18	77	15	0.9

A comparison of the analysis of the marl with those of the ash, shows how abundantly it supplies the mineral substances needed for the growth of vegetation.

The peculiar adaptation of these marls to the growth of potatoes has long been known. Causes for this may be seen in the large amount of potash and of oxide of iron, which are found both in the marl and in the ash. That the latter substance has an important influence, may also be inferred from the well known fact, that the marls near the surface, and which have been most changed by the action of air and moisture, but still contain their oxide of iron, are as useful as any others for a single crop of potatoes.

The growth of white clover upon marl banks, or marl heaps, has come to be a test of their character; those containing lime soon become covered with a spontaneous and luxuriant growth of this clover; on the contrary, none of it is ever seen upon marls

which are acid in their properties, or which contain sulphate of iron. An explanation of this is at once perceived, in the composition of the clover ash.

Those who have used the rich green marls with beneficial effects for a few years, have observed that they do not answer as good a purpose as at first, and that liming fields which have been thus treated, makes an excellent change, increasing the crops, and restoring to the land the property of being benefitted by marl. The analysis shows that such marls contain but little lime; and their failure to act may be due to this cause. Those marls containing a large amount of lime never fail to produce good effects, though applied for years without any other manure. Lime appears to aid the marl, not only by furnishing this constituent when it is needed, but also by rendering the marl more soluble, and thus more free to give up its fertilizing principles to the growing plants. This has been shown in instances where the marl, when applied alone on land, produced no effect; but on liming it well has produced as good crops as marls of the highest repute. And that this effect was due to the marl, was known by the same dressing of lime being applied upon other and adjoining fields, which had not been marled, and no perceptible effect was observed. It produces the same effect, too, upon many soils which, though fairly green with the marl grains in them, were yet almost barren; it has brought them at once to a high state of fertility. There are marl pits opened in all the beds, which are reputed to be worthless, and which do seem to be quite inert; though analysis shows them to contain the same constituents with other marls which are active in their properties. The size of the marl grains, undoubtedly, has some influence on the quickness of their action, the finest being best. But besides this, some of them are more readily soluble than others. Those which are dug in valleys or in any locations where the surface water does not soak through them and run off below, where they have never been drained and dry, are always the easeist dissolved, being

readily decomposed by carbonic acid and water.* Many of the *dry bank* or *hill* marls appear to have undergone a kind of seasoning, such as stone goes through when taken from the quarry and exposed to the weather—they become harder and less easily acted on. The experience of the farmers with the active marls lends support to this view; in that they find the heavy dressings, applied at long intervals, as was formerly the practice, are not as beneficial as the same amount applied in lighter and more frequent coats. When first taken from the pit it is most active, and gradually becomes inert. Lime mixed with such marls, or applied on them in the soil, will render them more easy of decomposition, and thus favor their action.

The marl is used in great profusion in some localities, where it is easily obtained, but its beneficial effects are to be seen in cases where only small quantities are used—small enough to sow it over the ground like ashes. And it would undoubtedly be found to pay well, even if carried long distances by railroad, or by water. Since the opening of the Freehold and Jamesburg Railroad, large quantities of marl have been sent over that road to various places on the Camden and Amboy Railroad. The New Jersey Farmer gives the amount carried over the road during the past year at 360,000 bushels. Much of this is hauled from Squankum, (seven miles) by teams. It is worth seven cents a bushel at Freehold.

The opening of other railroads through to different parts of the marl district, would be useful in extending the benefits of this valuable fertilizer. There are now a number of places where it is readily accessible by water. On the shore of Sandy Hook bay, below the Nevesink lights, the marl could be run from

* Prof. Booth, in his Report on the Geology of Delaware, p. 150, says that, "by a well charged solution of carbonic acid a large portion of the green sand was decomposed in a few days, and a weak solution induced the same effects in a few weeks."

the banks directly into boats. And the same convenience of access is found for several miles along the north shore of the North or Nevesink river, and at several places farther south the marl is found, but a short distance from the sea shore. On the Delaware side of the State, several of the creeks are navigable quite up into the marl district, and vessels could be cheaply loaded in them.

Analysis of shell marls from Stoe Creek.

Water	2.400	7.00
Silica and sand	79.160	42.70
Peroxid of iron	3.562	10.30
Alumina	.442	
Potash	1.227	0.68
Lime	7.500	21.43
Magnesia	0.884	0.20
Phosphoric acid	0.420	0.98
Sulphuric acid	0.166	
Carbonic acid	4.030	16.03
	99.791	99.32

These marls were from the pits of Isaac W. Elwell, Stoe Creek township, Cumberland County. They are of the common bluish green color, and contain a large per centage of crumbled shells.

Experience has shown these marls to be possessed of valuable fertilizing properties. Their action is said to be not as quick as some of the greensand marls, but they produce a permanent improvement in the soil.

The various deposits of oyster and clam shells which have been mentioned, have not been analysed. The shells are evidently unchanged, or only slightly crumbled, and are mixed in with blue mud, such as now forms in the bays and marshes where tide-water flows, and more or less sand. Their value

must depend partly on the lime which they contain, and partly on the improvement in the texture of the soil, which their earthy matter would effect. They have not yet received, from farmers, the attention which they deserve.

The calcareous layer which is the top of the second bed of greensand, and which is known in different parts of the district as *yellow marl*, *gray marl*, *lime sand*, &c., consists of carbonate of lime, from crumbled and powdered shells, corals, &c., mixed with white sand and scattering grains of greensand. The carbonate of lime in it is from 50 per cent. upwards, in the whole mass, and is its valuable ingredient. Farmers are in the habit of comparing its effects with those of green marl, and judging its value in that way. They are quite unlike in their action, and wherever it is possible should be applied alternately to the soil, each tending to develop the useful properties of the other.

The blue-mud of the tide marshes along the ocean, bay, and creek shores of all the southern part of the State, is a valuable repository of fertilizing material. In othe rcountries where agriculture is much advanced, such deposits are highly prized for improving the texture of light soils, and for furnishing useful mineral constituents to it. Its extreme fineness renders it peculiarly valuable for the latter purpose. Its use is but just commenced in New Jersey, but wherever tried it has given satisfaction. From a number of instances of its use, the two following may suffice. Near Cape May Court House the salt-marsh mud has been used by R. C. Holmes, Esq. He composts it with one twentieth as much stone lime, and leaves it exposed to the weather for a year or two, to leach out the salt. On his sandy loam it produces fine crops of wheat, corn, and grass. Mr. Coombs, of Port Elizabeth, has used mud from the Maurice river marshes, to fine advantage. His soil is a very poor and light sand—so poor that, with ordinary cultivation, it does not yield more than ten bushels of corn to the acre. By the application of from sixty to eighty loads of mud to the acre, it is made a

permanently retentive soil, which, with good cultivation, yields fifty bushels of corn, or twenty bushels of wheat, to the acre.

The taking of fish, king-crabs, &c., to be used for manure, has been occasionally practiced by our farmers near the sea shore, and their use in a raw state, or in compost, is well understood in the immediate neighborhood where they are caught; but few attempts have been made to preserve them in a state for transportation to a distance. The remarkable effects which have attended the use of guano, and other highly concentrated manures, and the increasing demand for them, have turned the public attention to our own sources of supply, and the preparation of portable manures, from the products of our own country, is felt to be of great importance.

Immense quantities of moss-bunkers and other fishes, are caught upon our shores, but no attempts are known to have been made, in the State, to prepare manure from them; and no systematic effort has yet been made to collect statistics of the numbers which are or might be annually taken. Some particulars have been collected in regard to the king-crab, which are worthy of attention.

This creature, which is known under the names of Horse-foot, King-crab, and Sea-spider—the *Polyphemus occidentalis* of the naturalists—is common on all our Atlantic coast; but it seems to find a particularly congenial location in the lower part of Delaware Bay. It comes to the shore to deposit its eggs in the sand, in the early part of summer; the largest number, it is said, in the old of the moon in June, though they are abundant for several weeks before and after that time. They come in such numbers that the beach is literally covered with them for nearly forty miles up the bay-shore, from Town Bank in Cape May County. They weigh, on the average, about four pounds each; and, at a very moderate calculation, a million of them could be picked up on a mile of beach in one season. They are used in great numbers as feed for hogs, and their eggs are shovelled up in wagon-loads, and carried off to feed to chickens. Many of

the Cape May farmers have thrown them up in piles, and composted them with earth, as a manure for wheat, and the effects they produce are remarkable. The poorest soils that can be found, by a dressing of from 2,000 to 4,000 on an acre, will produce twenty or twenty-five bushels of wheat, and thirty bushels is not an uncommon crop. This testimony in regard to their fertilizing action is confirmed by the experience of a number of farmers of whom I have inquired, and yet there is a singular prejudice against them. It is said that corn or clover will not thrive on the soil where they have been used—but that they bring in sorrel. This latter fact has been mentioned by several, but I am inclined to think it a difficulty of but little moment, even if entirely correct. The crabs contain but little mineral matter, and there may be a deficiency of that in the soil, after a heavy crop of wheat has been raised; but a dressing of lime or ashes will effectually correct this deficiency. Mr. Thos. J. Bate, of Fishing Creek, has used them in this way, and has had good crops of corn and grass after them. Some others have succeeded in the same manner, by the use of lime.

Mr. Jonathan Ingham, of Salem, and Mr. Thomas Beesley, of Dennisville, have erected a factory at Goshen, for preparing a manure from these crabs. They dry and grind them, and then mix them with charcoal, plaster, and other deodorizing materials, and sell the preparation under the name of *Cancerine*. It is a black powder, of a fishy smell, and when wet and allowed to stand for a few days, gives off a strong odor of ammonia. Prof. Booth, of Philadelphia, has analyzed it with the following results:

Analysis of Cancerine.

Ammonia	25.57	per cent.
Organic matter	29.23	"
Phosphate of lime	5.90	"
Sulphate of lime	10.32	"
Silex	1.20	"
Water	26.10	"
	98.32	

The ammonia, which many agriculturists esteem as the valuable fertilizing ingredient in concentrated manures, is more than one quarter part of this; in guano it rarely amounts to more than one sixth. It contains less mineral matter than guano, but this is a deficiency which may be supplied at a much lower price—by lime, wood ashes, greensand marl, &c.

The cancerine is sold at a rate considerably lower than guano; and though its value has not yet been shown in the crops raised by it, yet I cannot but think it promises to be a most valuable addition to the fertilizers now in use; and that it is the beginning of a branch of manufacture, which must supply our farmers with guano when the deposits on the Peruvian islands are exhausted.

Analysis of a Woodbridge fire-clay.

Water	14.640
Silica	39.760
Protoxid of iron and manganese	0.940
Alumina	42.850
Potash	0.477
Lime	0.398
Magnesia	0.650
	99.715

This specimen of clay was taken from the bank of Mr. P. Melick, of Woodbridge, Middlesex County, and is a sample of the best fire or alum clay.

Analysis of a South Amboy fire-clay.

Water	14.480
Silica	39.710
Peroxid of iron and manganese	0.260
Alumina	44.000
Potash	0.545
Lime	0.342
Magnesia	0.326
	99.663

This specimen of clay was taken from the bank of Mr. Coleman, on Burt's creek, near South Amboy. It is a good specimen of the variety of fire-clay, which is used for facing paper hangings, and is sold as *paper clay*.

Fire bricks made from these clays, stand an intense heat better than the imported bricks, and being afforded at a lower price, they are gradually coming into use, in place of the foreign ones. The material for not less than 50,000,000 fire bricks is annually sent into market from Woodbridge, Perth Amboy, South Amboy, and its vicinity. Fire clay is worth from $2 to $2 50 a ton, and first and second quality fire bricks are worth $35 and $30 a thousand.

For the facing of paper hangings, these clays are unequalled in the fine surface they give; though they are not quite as white as some others. There are not less than two thousand tons sold annually for this purpose. The price is from $8 to $9 a ton, in barrels.

This clay supplies all the alum works in the country. About two thousand tons a year are consumed in this manufacture. Its price is the same as that of fire clay.

In the making of porcelain and fine earthen ware, but little is done in our country. The potteries at Jersey City, and at Green Point, are said to use these clays in making their ware; and they are used at Trenton in making porcelain door knobs, and other door trimmings. The clay answers every requirement in point of quality and color, and is afforded at less than a quarter the price for which it could be imported.

Analysis of a stoneware clay from South Amboy.

Water	6.080
Silica	71.800
Protoxid of iron	1-314
Alumina	19.050
Potash	0.613

Lime	0.314
Magnesia	0.794
	99.965

This is a specimen of the stoneware clay from the bank of J. H. Clark, of South Amboy, and is a fair sample of the clays of that vicinity.

This clay is valuable for the superior quality of stoneware made from it. It is sent to all parts of our country, and into Canada. About ten thousand tons a year are needed to supply the demand. Its price is $2 a ton.

5. *Progress of the survey in different counties.*

The progress of the work in the different counties, has been pretty nearly indicated in the preceding part of the report. The geological survey is not completed in any of the counties of the southern division.

In Monmouth County most of the labor is done. Specimens of marls, fossils, &c., have been collected from all parts of the county. The County Agricultural Society, through committees in every township, have, also, collected such specimens of marl as they judged important to have examined, and have forwarded them to me. The different formations have been accurately traced out, over about two-thirds of the county, and levels for constructing the proper explanatory sections have been carried over the same portion. The chemical examination of the marls is well advanced.

In Salem the survey is carried over nearly the whole county. With the assistance of William Snowden, who resided in the county for a considerable time, and is familiar with it, specimens have been collected from the principal marl diggings, also many soils and fossils; and most of the notes necessary to a full geological description of the county have been made.

Cape May is nearly completed; all parts of the county

A CEDAR SWAMP, CAPE MAY CO.

have been visited, and specimens of interest collected. A further examination of some of the marshes and swamps, and the survey will be finished.

In Cumberland and Middlesex counties, a considerable amount of work has been done.

A few points of interest have been noticed in the course of the survey, which not coming appropriately under any of the preceding heads, may be presented here.

The *Cedar Swamps* are a remarkable feature in the forests of southern New Jersey. They are common in all the counties south of Monmouth, but probably the most extensive are in Cape May, and the adjoining parts of Cumberland and Atlantic counties. The Cedar Swamp creek, which runs into Tuckahoe river, and Dennis creek, which runs into Delaware bay, head in the same swamp, and the whole length of the two streams, a distance of seventeen miles, is one continuous cedar swamp. The wood is the white cedar, the *Cupressus thyoides* of the botanist. The original growth of trees which covered these swamps at the first settlement, has all been cut off; scarcely any are now to be found more than one hundred years old, and it is usual to cut them at fifty or sixty years. Formerly they attained a great age. Mr. Chas. Ludlam counted seven hundred rings of annual growth in an old tree, which was living when cut down, and Dr. Beesley counted 1080 in another. The trees stand very thick upon the ground and grow rapidly at first, but as they increase in size and crowd each other, the tops become thin, and the annual growth exceedingly small. The rings near the centre of a large cedar log are often almost an eighth of an inch in thickness, while those near the bark are not thicker than paper. Trees four or five feet in diameter have been found, but this is uncommon, and in the second growth timber they are much smaller.

The accompanying cut was made from the drawing of a swamp of ninety years growth. A swamp of sixty years growth will yield from 4000 to 7000 split rails, halves and quarters; be

sides the top poles, or *cullings*, and a considerable number of logs for sawing. And in the older swamps, the product is proportionally large. The value of an acre of such timber is from $400 to $1000, and some acres are thought to have yielded a larger sum still. The soil in which these trees grow is a black, peaty earth, composed of vegetable matter, which when dry will burn.* This earth is of various depths, from two or three feet up to twenty or more—and the trees which grow on it have their roots extending through it in every direction near the surface, but not penetrating to the solid ground. When this earth is open to the sun and rains, it decays rapidly, but when covered with a growth of trees, and so shaded that the sun does not penetrate to the ground, it increases rapidly from the annual fall of leaves, and from the twigs and small trees which die and fall. Mr. Charles Ludlam recently found a log sawed off at both ends, which was entirely buried in the swamp. It was about a foot in diameter, and he knows that it was cut fifty or sixty years since. This process of covering and preserving timber has been going on for a long time. Trees are found buried in this peaty earth at all depths, quite down to solid ground. The buried logs are quite sound, the bark on the under side of many of them is still fresh in appearance, the color of the wood is preserved, and its buoyancy retained. When these logs are raised and floated in water, it is observed that the side which was down in the swamp is uppermost. The buried trees are some of them found with their roots upturned, as if blown down by the wind, and others are broken off as if they had stood and decayed, till too weak to support their own weight. The accompanying view, taken in the swamp of Mr. Henry Ludlam, will give an idea of the manner in which the logs lie. It, of

* The amount of ash left by its burning is astonishingly small. In two trials which I made, the amount of ash in the dried earth was only three and a half per cent. It was almost insoluble in acids, and had not the slightest alkaline taste. It was mostly silica.

FALLEN TIMBER IN CEDAR SWAMP CAPE MAY CO

course, can show only a few of the uppermost ones; and these are unusually well exhibited, the swamp having been cut off fifty years ago, and its surface much decayed by exposure to the sun and rain during that time.

The most prominent object in this drawing is a large log, which is seen extending across from one side to the other; another log partly decayed lies across it, and underneath another appears, which has had a piece cut out for working into shingles; other logs are also seen, lying some over, others under those already mentioned. To the right of the large log is a stump, which has its roots running under the log, showing that it is as old, or older, than the fallen tree; to the left, and partly on the log, with one of its large roots growing across, another old and decayed stump is seen. From its position, we may safely infer that the latter has grown, died, and decayed, since the large tree fell.

These logs are so abundant in some parts of the swamp, and in the salt marshes bordering on them, that a large number of men are constantly occupied in raising and splitting them into shingles. In Mr. Ludlam's swamp, this business was commenced fifty years ago, and has been carried on every year since, and though the logs are not quite so plenty as at first, enough are still found to repay the workmen. The size of the logs is from one and a half to three feet, though four feet is not uncommon, and I have heard of them five or six, and in one instance seven feet in diameter. Occasionally a log is found that will work for thirty feet, but generally the length is less than this.

In searching for logs, the workman uses an iron rod, which he thrusts into the mud till it strikes one; then, by repeated trials, he judges of its direction, size, and length. The next trial is by digging down, and if possible getting a chip from it. By the smell of this, the experienced shingler can tell whether the tree is a *windfall* or a *breakdown*, or in other words whether it was blown up by the roots, or broken off. If judged to be worth

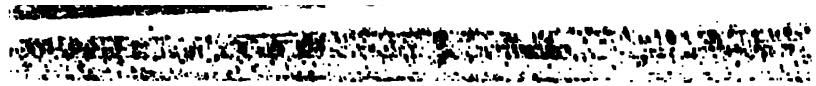
working, the stumps, roots, and turf, are removed from over the log, and the earth dug out. The trench which is thus made, of course, is full of water. There being no grit in the earth, tools can be used in it without injury, and the logs are rapidly sawn off by a one handled cross-cut saw, which can be worked directly into the soft earth. As soon as the log is cut off, and loosened by means of levers, it rises and floats in the water. It is then divided into shingle cuts, quartered, and thrown out to be split into shingles, and shaved; when it is ready for market. The annexed drawings show the different operations in this singular business. That in the swamp shows the floated log being cut into shingle lengths, and the shaving of shingles going on in the background. The view in the salt marsh shows the stumps still standing; also the operation of cutting off a log, preparatory to raising; and the splitting up of another log.

It is said that for five years past the average number of these shingles, sent from Dennisville, is not far from 600,000 a year. They are worth from $13 to $15 a thousand. About 200,000 white cedar rails have been sent from the same place this year. They are worth from $8 to $10 a hundred.

The view on the marsh was taken near Dennisville, looking towards Delaware Bay. It was just after a northeast storm, and the vessels seen are in Maurice River Cove, where they have run for shelter. It is said that as many as 500 vessels have been seen lying here at once, waiting for a change of wind. A breakwater is very much needed on the inside of Cape May; that at Lewiston, on the Delaware side, being insufficient for the number of vessels that need shelter. As it is now, many of the vessels going out the Capes, if met by a storm, put back and sail twenty miles up the bay to obtain a shelter, which should be found near the point of the Cape. Besides the loss of time in sailing so far back, the vessels in the cove are liable to be blown ashore by a change of the wind. A breakwater at the point mentioned would be of great advantage to our coasting vessels generally.

SAWING CEDAR-LOGS, AND MAKING SHINGLES.

RAISING OR MINING BURIED CEDAR TIMBER.



The accompanying sketch was taken near the point of Cape May, on the bay-shore. It gives a good view of the sand-beaches, and the vegetation they support. It was taken the day after the preceding, when the wind had changed, and the vessels were sailing out of the bay. Cape Henlopen is seen in the distance on the right.

Gravel Bricks.—A new building material has been introduced in Cumberland, and some of the adjoining counties, which promises to be both cheap and durable. The common clean gravel and coarse sand of the country is mixed with one twelfth its measure of stone lime, and made into bricks. These bricks are sun-dried, and then laid up into walls. They are cheap, durable, and but little affected by the changes of the seasons.

In making, the gravel is laid on a common mortar bed—and the lime, which is slacked and made into a thin putty in a lime trough, is then run on the gravel, and the whole worked up into mortar. The bricks are usually made as large as is convenient for handling, and of dimensions to suit the work for which they are intended. The moulds are made, several in the same frame, as deep as the thickness of the brick, and without any bottom. They are set on smooth ground, and filled with mortar. This is worked in a little with the shovel, and struck off at the top. In ten or fifteen minutes the mortar will have set, so that the moulds can be taken off. The bricks are soon dry enough to handle, when they can be piled up, and allowed to dry thoroughly. They are laid in mortar similar to that from which the bricks are made, and the outside of the buildings is roughcast with the same.

The method was introduced at Bridgeton by Robert C. Nichols, Esq., manager of the Cumberland Iron Works. The accompanying cut is a view of Mr. Nichols' residence, which is made of this material. Several buildings of this kind have been erected in Bridgeton, and its vicinity, within the last eight or ten years; and in Norristown, Pennsylvania, it has been in use for seventeen years past. It has stood well, growing harder and more solid every

year. The bricks have come to be a regular article of manufacture in several places. Those of 12 by 9 by 6 inches were selling in Bridgeton, last summer, for $20 a thousand, and they could be laid, and mortar found, for $10 a thousand; which is less than half the cost of the same measure of red brick wall. The material of which these bricks are made being found almost everywhere, and the labor of making and laying them up very simple, farmers and others who have control of labor, can make and lay them at times when the expense of the work would not be felt, and thus a saving much greater than that mentioned could be made. When first laid up they are not quite as strong as other bricks; and greater care is necessary in making a solid foundation; otherwise unequal settling, and cracks in the walls, will result. Care must be taken to make them so early in the season, as to be entirely dry before the winter's frost.

Mr. Fowler, of New York, in his work entitled, "Gravel Wall Cottages, or Homes for all," has described a method of forming the wall directly from the mortar. It is done by setting up boards on their edges, where the wall is to be built, and as far apart as the thickness of the walls. The mortar is filled in between these, and allowed to remain till it has set, when the boards are raised to the top of this wall, and again filled, and so on till the wall is completed. This method, in the hands of experienced workmen, is undoubtedly cheaper than the other; but to unpracticed laborers would, as I believe, be attended with more difficulties. The material is used in the construction of houses, shops, stores, walls for gardens, yards, &c., for all of which purposes it gives entire satisfaction.

GEO. H. COOK,
Assistant Geologist.

Rutgers College, New Brunswick, Dec. 29, 1855.

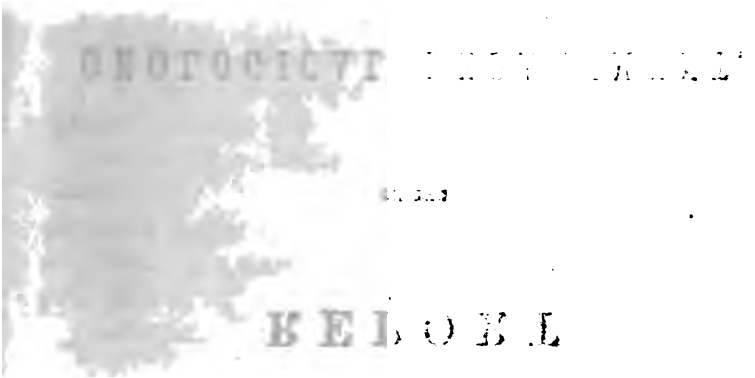
Dwelling built of concrete bricks, Bridgeton, Cumberland Co.

REPORT

ON THE

GEOLOGICAL DEPARTMENT.

NORTHERN DIVISION OF THE STATE.



REPORT

ON THE NORTHERN DIVISION OF THE STATE.

The geological researches in the northern division of the State, have been chiefly confined to the azoic rocks of Sussex, Morris, and a part of Passaic and Warren Counties; all of which are embraced within the district known as the Highlands of New Jersey.

In reporting the progress of the geological researches in this district, I propose to give:

1. A general description of its physical features.
2. A general description of its geology.
3. Local details of its boundaries.
4. An enumeration and local details of its principal metalliferous deposits, showing, by means of sections, their geological position, and the extent to which the most important iron mines have been worked.
5. The art of mining, as applied to developing these metalliferous deposits.

PHYSICAL GEOGRAPHY.

The Highlands of New Jersey are composed of a series of parallel mountain ranges and hills, extending in a northeasterly and southwesterly direction, across the State, from the New York State line to the Delaware river.

This district, at the State line, is about twenty three miles wide, and reaches from the southeastern base of the Ramapo mountain and river, in Bergen County, to the northwestern base

of the Pochuck mountain, three quarters of a mile southeast of the Wallkill river, in Sussex County. Its widest part, which measures twenty-five miles, would correspond with a line drawn from the southeastern base of Mount Kimble, near Morristown, to the northwestern base of the Jenny Jump mountain. At the Delaware river its width does not exceed eight miles. Its average width may be stated at eighteen miles; its length at sixty miles; and its area at about one thousand and eighty square miles, or about one seventh of the whole State.

This series of hills, and mountain ridges, is a continuation of the Highlands of Putnam, Westchester, Rockland, and Orange Counties, in the State of New York; and presents the same general physical aspect, geological formation, and mineral products. Its physical features are entirely dissimilar to those of any other portion of the State, presenting, as is nowhere else done, a succession of mountain ranges, which do not run parallel with the general direction of the Highlands, but, ridge succeeding ridge, rising and disappearing one after another, cross obliquely the belt of these mountains. There are no continuous ridges exceeding a few miles in length, with the exception of the Green Pond mountain, the geological formation of which is different. The southwestern termination of these mountain ridges is generally steep and rugged; while their northeastern has a gentle or undulating slope, and disappears beneath the next succeeding ridge. This succession of ridges corresponds with the rocky strata and metalliferous deposits, and has been caused, undoubtedly, by dislocation of the strata, and lateral heaves of great masses of the rocky formation. Evidences of an elevating power acting from the northeast towards the southwest, as well as of a lateral power, are manifest throughout the whole extent of the Highlands. A true exposition of these would demonstrate the causes which have formed this succession of mountain ranges, and would be valuable, in an economic view, as serving to trace out the metalliferous deposits. I will, at this time, mention only

POCHUCK MOUNTAIN AND VERNON VALLEY, SUSSEX CO

a few of the principal series of mountain ridges, with their intervening valleys, in the counties of Sussex, Morris, and a part of Passaic and Warren, deferring a detailed description of them until the completion of the topographical map (now rapidly progressing,) which will represent, not only their relative positions with each other, but also with the whole belt of the Highlands.

MOUNTAINS.

Commencing with the northwestern boundary of this district, the different series of mountain ridges may be enumerated as follows:

1st. The series forming the Pochuck mountain, commencing with Mount Adam and Eve, in the State of New York, and terminating near Hamburgh, Sussex County. Rising again, a little northwest of Franklin Furnace, in the form of low, rounded hills, and sharp ridges, this series continues southwesterly to Andover, and includes Pimple Hill, Stirling Hill, the precipitous bluffs northwest of Sparta, and the Andover mountains.

The accompanying drawing, taken from the hills one mile east of Franklin Furnace, presents a view of Pochuck mountain and Vernon valley; and illustrates the characteristic features of the series of ridges, with their gentle inclinations towards the northeast, and their abrupt terminations towards the southwest, together with their general direction, as compared with the mountain belt described above.

2d. The range including the Wawayanda, Wallkill, Hopatcong, and Schooley's mountain, rising in some places to the height of seven or eight hundred feet above the adjoining valleys.

On the summit of this mountain range are numerous lakes, ponds, springs and swamps, including the Wawayanda and Hopatcong, Norman and Senecawana lakes, hereinafter described, as well as the celebrated Chalybeate spring of Schooley's mountain.

3d. The Green Pond mountain range, which differs from the

others in being one long, narrow, and almost uninterrupted ridge, from Succasunna plains to the State line, and which, being of a different geological formation, affords a striking contrast with the irregular and broken outlines of the adjoining belt of hills of azoic rocks.

4th. The Ringwood, Copperas, Splitrock, Hibernia, Mount Hope, Mount Pleasant, and Mount Ferrum mountains, a range differing from the others, in that it contains the principal iron mines of the Highlands.

5th. The series forming the south-eastern boundary of the Highlands, and which includes the Ramapo, Pompton, Boonton, Trowbridge, Washington, and Kimball mountains.

The annexed drawing, taken from Sugar Loaf hill, two miles and a half west of Morristown, gives a view of a part of this boundary, and especially of the Trowbridge mountain. The same general features of the ridges, their direction, outline, slopes, etc., are seen here, as at the northwestern boundary—the Pochuck range.

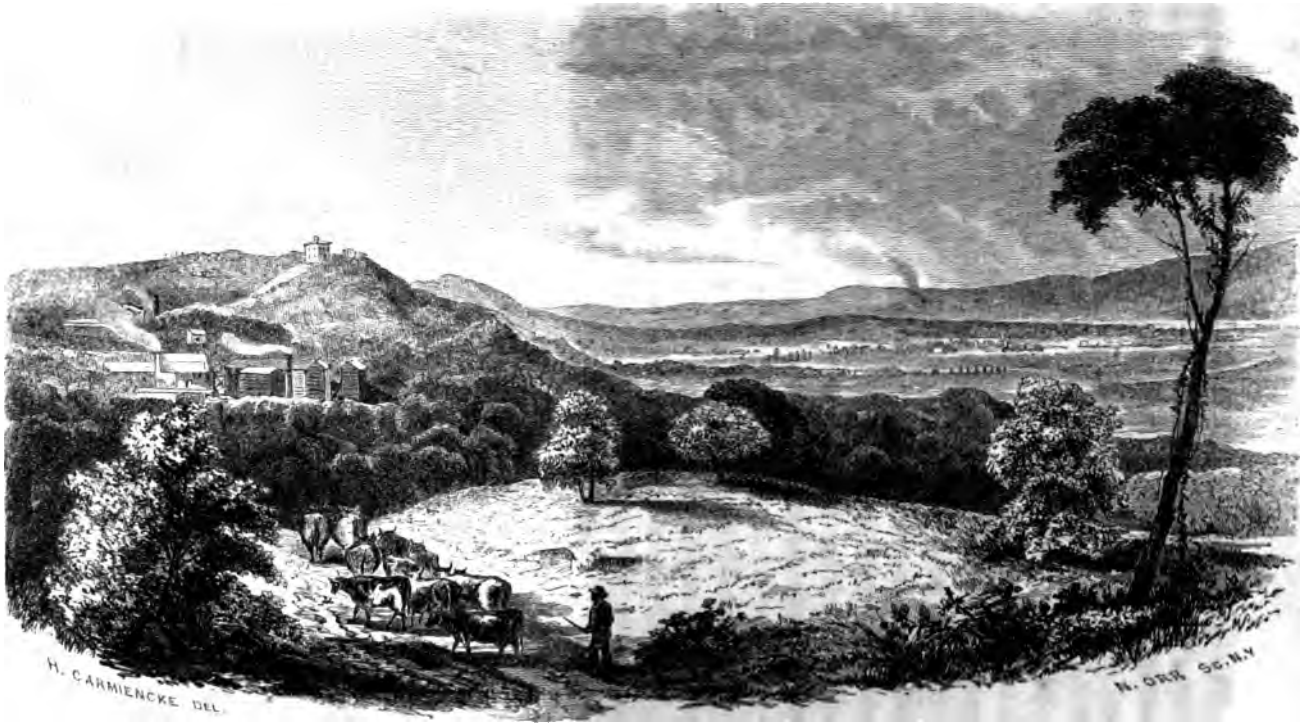
The foreground, to the base of the mountain, represents Watnong plains, (Morris plains) with their undulating surface, and low, rounded hills of drift, and disintegrated gneiss. The bold, elongated summit at the left, is the Watnong mountain—a spur of the Trowbridge mountain.

VALLEYS.

Parallel with the mountain ranges are numerous intervening valleys, varying in length, from one to twenty, and thirty miles, which being enumerated in the order just observed in naming the mountains of this district, are:

1st. The most north-westerly, within the Highlands, the Vernon and Wallkill valleys, which extend from the State line to the head waters of the Wallkill river, about three miles southwest of Sparta. It is bounded on the north by Pochuck mountain, and Pimple Hill range, and on the southeast by the Wawayanda, and Wallkill mountains.

TROWBRIDGE MOUNTAIN AND WATNONG PLAINS, FROM SUGAR LOAF HILL, MORRIS CO.



MOUNT FERRUM, SUCCASUNNA PLAINS AND SCHOOLEY'S MOUNTAIN, FROM RANDELL HILL, MORRIS CO

This valley varies in width from a half to two and a half miles; its greatest breadth being near the State line. Its northeastern, or Vernon portion, is drained by the Wawayanda and Black creeks; its southwestern, or Wallkill portion, by the Wallkill river.

2d. Greenwood valley, situated in Morris County, between the Wawayanda and Greenpond mountains, seven miles in length, and drained by Belcher's creek and Greenwood lake.

3d. Longwood and Berkshire valleys, in Morris County; bounded on the northwest by the Wallkill and Hopatcong mountains, and on the southeast by the Greenpond mountain; from half a mile to one mile in width, twelve miles in length, drained by the Rockaway river, and possessing a rich and fertile soil.

4th. Succasunna plains, which is a continuation of the same valley, towards the southwest, being from two and a half to three miles wide, and six miles long.

This valley is bounded on the northwest by Schooley's mountain, and on the southeast by Mount Ferrum. It has a light, sandy, and gravelly soil, and is drained by the Black river. The accompanying view, taken from Randall hill, about one mile from McCainesville, on the turnpike leading to Dover, represents, near the foreground at the left, the Dickerson and Byram mines, situated on Mount Ferrum, and, in the background, the Schooley's mountain range, with the Succasunna plains intervening.

5th. German valley, about ten miles long, and from one to two and a half miles wide.

This valley is bounded on the northwest by Schooley's mountain, and on the southeast by a mountain ridge, rising at the southwestern part of Succasunna plains, and separating it therefrom. It is drained by the south branch of the Raritan river, and possesses a fertile soil.

6th. Green Pond valley, which lies at the base of the Green Pond mountain.

This valley extends from Charlottenburg to Mount Pleasant. It is about eleven miles long, from one-half to one and a half miles wide, and is drained by the Green Pond (Burnt Meadow) brook.

7th. Beachglenn and Splitrock valleys, which lie between two ranges of mountain ridges, extending from Rockaway to Durham, and designated as the Hibernia and Splitrock mountains.

The length of these valleys is nearly ten miles, and their width varies from a half to one and a half miles. They throw off several minor valleys, corresponding with the tributaries of the Beaver and Beachglenn brooks, which flow through their principal parts, affording an excellent water power, that has been made available for more than a century, in driving forges for the manufacture of iron from the ore of the adjacent mines. The hills upon either side rise from fifty, to six hundred feet above the trough of the valleys; and their peculiarly precipitous southwestern extremities, with their oblique direction to the general course of the valleys, and the many dislocations of the rocks, produced here by powerful perpendicular and lateral heavings, unite to afford that wild and picturesque scenery so characteristic of the Highlands. The surface is level, or gently undulating; contains large deposits of peat and muck, and affords a rich fertilizer for their loamy soil.

9th. Rockaway, Den, and Indian Brook valleys, which lie in Morris County, along the same general range of mountains, and from one to three miles southwest of the last described valleys.

These valleys extend from the vicinity of Bloomingdale, at the Passaic County line, southwesterly to Denville, Walnut Grove, and Mendham, and thence to the Somerset line. They vary from deep gorges to level and undulating plains, of one and two miles in width. The first two are drained by the Rockaway river and its tributaries, which divide into numerous rivulets and brooks corresponding with the minor valleys, extending to some distance between the spurs of the mountain ridges. The last

mentioned is drained by several small tributaries of the Whippany river, as well as by one of the branches of the Raritan.

10th. Lubber's valley, which commences in the south-western part of Sparta Township, near the source of Lubber's run, and continues in a southwestern course to its junction with the Musconetcong river, a distance of about eight miles.

This valley varies from one to three-fourths of a mile in width, and is, for the most part, low and comparatively level, containing a large area of marshy lands. The slightly elevated portions in the upper (N. E.) part, as well as the slopes of the hills between which the valley lies, are generally cultivated, and comprise the greater share of the tillable land in Byram Township. On the southeast, it is bordered by the continuation of the Wallkiil mountains, and on the northwest by the elevated lands extending northeast from the Alamuche mountains.

11th. Ringwood valley, which commences at the State line, and, extending in a southwesterly direction to Winoke, a distance of seven miles, deflects southward nearly to Pompton, where it expands, and forms what are called the Pompton Plains.

The whole length of this valley is ten miles, and its width varies from three-eighths to one mile. It lies between rough and irregular hills and ridges, from seventy-five to one hundred and fifty feet in height, and is drained by the Ringwood river and its minor tributaries. The surface is undulating throughout its whole length, except through Winoke, where, for a distance of two miles, it is remarkably level.

LAKES AND RIVERS.

Throughout all nature there is nothing, perhaps, more interesting, and, withal, more simple, than the means employed for irrigating and fertilizing the earth. Observation shows us that the clouds gathering around and above the summits of the mountains, pour upon them their waters, which, collecting in depres-

sions, form ponds and lakes, or, percolating in the fissures of the rocks, burst forth in springs, or, flowing into ravines, form rivulets, which unite and swell into rivers, and finally empty into the ocean, the great receptacle of waters, to pass again into the atmosphere, and again to visit the mountain tops and valleys.

The drainage of a district of country by its water courses, has not been inaptly compared to the circulation of the blood in the human body. As the impure blood from every part of the body is conducted by means of the veins to its great receptacle, the heart, and thence to the lungs, to be purified, and again distributed throughout the whole system, so the impure water from every mountain, valley and plain, is carried, by means of rivulets and rivers, into the ocean, where it is purified and again distributed to every portion of the earth.

The Highlands form the great water slope of the northern and central portions of the State. The principal lakes of this district are situated upon the mountain summits, whence springs burst forth on every hand to form its principal rivers.

The Wallkill river.—Following the arrangement that was observed in the forgoing enumeration of mountains and valleys, we begin, in speaking of rivers, with the most northwesterly of the principal streams, which is the Wallkill river.

This river rises in Byram Township, Sussex County, and flows in a north-northeasterly direction, through the village of Sparta, and thence between the Wallkill mountain and the Pimple Hill range, through Hardiston Township. Thence taking a southeasterly course to the State line, it forms the boundary between Wantage and Vernon, and completes a distance of twenty-three miles in the State of New Jersey. From the State line, it continues its northeasterly course to the Hudson river, into which it empties about three miles from Kingston. From its source to Sparta, it passes, for the most part, through low, marshy lands; and at Sparta its volume is much augmented by a stream which

enters it from the east, and which furnishes, at a number of places in and near the village, available water-power, that is employed in driving forges, flouring, and saw-mills. Passing thence to Franklin Furnace, the fall of the stream is not very great; and, indeed, two miles of this part of its course is over very low lands. But at Franklin Furnace an excellent water power is again afforded; and the stream is still further increased by several tributaries, which take their rise in, or at the base, of the Wallkill mountain. Between Franklin Furnace and the State line, the volume of the stream is once more increased by a number of tributaries, but its fall is insufficient to furnish good water power, except at Hamburg. Its principal tributaries below Franklin Furnace, are Nova Scotia brook, a stream flowing from Mud Pond, upon the Hamburgh mountain, Beaver creek, flowing into it about two miles below Hamburgh, and Papakating river, a stream of inconsiderable magnitude, rising in Frankford Township, and flowing into it about one mile and a half southeast of Deckertown. From the point where the turnpike from Deckertown, through Hamburgh, crosses the stream, it flows over low, marshy lands, known as "the Drowned Lands," which have a length of nine miles, and an average width of two thirds of a mile, and which cover an area of nearly four thousand acres. These lands are about three hundred and twenty-five feet above tide water in the Hudson river, and twenty feet lower than the Delaware river at the State line. The greater portion of them is covered with a dense growth of maple, white birch, and underbrush; and, except to a small extent along their borders, and upon Chandler's Island, these lands are wholly uncultivated. They consist of deposits of peat and muck of dark brown and black colors, well decomposed, and increasing in depth towards the centre. They are subject to annual overflows, and during a portion of the winter and spring are inundated by the backing of the water of the Wallkill from a point about ten miles below the State line. Through these lands, the current of the river is

scarcely perceptible; its width here is from forty to ninety feet, and its depth from three to six.

THE PEQUEST RIVER.—This stream is formed by the union of four distinct branches, which rise in the south southeastern part of Sussex County. The west branch, originating in a limestone cave on the farm of Samuel Hunt, Esq., in the township of Green, flows thence in a northeasterly direction to Springdale, where it deflects to the southeast, uniting with the east branch at Huntsville. The east branch is formed by the confluence of three minor branches, one of which has its source in a pond near Pinkney's Corner, another between Andover and Sparta, and the third in Panther Pond. From Huntsville to the Warren County line, the Pequest flows in a direction nearly parallel with the base of the northeastern continuation of the Alamuche mountain; and from the county line it pursues an irregular southwesterly course to Belvidere, where it empties into the Delaware river, about thirty miles from its source. This stream flows through a rich and productive section, varying much in appearance. The two branches, rising respectively in Green Township, and near Pinkney's Corner, pass through low, marshy lands, while the other two branches pass over rough and hilly districts, affording excellent water power in several places.

Between the county line and Long Bridge, the Pequest drains a large extent of marshy land; and between Long Bridge and Danville, it flows through the "Great Meadow," an uncultivated tract which covers an area of about five thousand acres.*

* The following is an extract from a letter of Geo. Green, Esq., upon the subject of the drainage of these lands; and upon an examination and report thereon:

"This subject would be a legitimate one for such a report, and the drainage could be suggested or recommended on public ground that would be incontrovertible. I should think that the State, County, Township, and the community in this vicinity, would all be benefitted by the bringing into profitable cultivation so large a tract of comparatively worthless land, and making it one of the most valuable and productive in the State."

As soon as detailed examinations are extended to that portion of the State, the subject will be thoroughly investigated.

Between Danville and Belvidere, however, it passes through a more hilly district, and the fall of water at several places, especially at Belvidere, is very considerable.

Musconetcong river.—This stream, originating in Hopatcong lake, flows through the canal reservoir to Stanhope, and thence in a west southwesterly direction to Waterloo, where, turning, and passing through the Musconetcong valley, it pursues a southwesterly course to the Delaware river, forming the boundary line between the counties of Sussex and Morris, as far as Byram, one mile below Waterloo. From this point to another, one mile below Stephensburg, it forms the boundary between Morris and Warren; and thence to its mouth, the boundary between Warren and Hunterdon counties. Its length is little less than forty miles. A large number of minor streams flow into it, the principal of which is Lubber Run. Its fall between Hopatcong lake and Waterloo, is sufficient to afford excellent water power at several places. Between Waterloo and Hackettstown, it passes into, and out of, the canal at a number of places, flowing through two or three marshy tracts of land. From Hackettstown to its mouth, it has, also, fall enough to furnish good water power. The land upon either side of it, through the Musconetcong valley, is generally cultivated; and the soil is very rich and fertile.

Passaic River.—This river, remarkable for being the longest and most circuitous in the State, as well as for the varied and beautiful scenery through which it passes, over every variety of surface, sometimes in the form of rapids, cascades, and precipitous falls, and at others, with scarcely a ripple to indicate its course, takes its rise near Mendham, in the Highlands of Morris County, and flows in a south by south-easterly direction, with such rapidity, as to afford available water power for a distance of ten or twelve miles, to Stony Hill. Here it receives the water of Dead river, and, turning suddenly, flows in a north-

easterly direction, along the southeast base of the range of hills designated as Long Hill, and thence along that portion of the continuation of the same range, known as the Short Hills, to Canoe brook. After flowing in a northwesterly direction, for somewhat more than a mile, it pursues a northeasterly course, over a level tract of meadow and marshy land, to Pine Brook, one mile and a half below its junction with the Rockaway river. Thence it takes a circuitous course along the base of the Towackhow mountain, for a distance of thirteen miles, to the Two Bridges, at its junction with the Pequannock river. From this point, flowing to Little Falls, it is intercepted by a dike of trap rock, which, crossing it, forms a natural dam, over which, for half a mile, the water falls fifty feet, forming small cascades and rapids. Then, flowing in a southeasterly direction to Paterson, it is again intercepted by a trap dike, forming the Passaic Falls, seventy feet in height. About one and a half miles below this point, it turns suddenly, and, flowing first in a southerly, and then in a southwesterly direction, it passes through Acquackanonck, Belleville, and Newark, and empties into Newark Bay.

In the southern part of Morris County, this river and its tributaries pass over two large tracts of meadow, marshy lands, occupying an area of twenty or thirty thousand acres. So level is the surface of these lands, that the river flows through them with a sluggish and almost imperceptible current, overflowing, at certain seasons of the year, vast numbers of acres lying upon its borders.

One of these tracts of meadow land, known as the Great Swamp, is situated on Black creek, between Chatham and Baskingridge. Not long ago a dense forest covered its whole surface; while, at present, a large portion of it is well timbered, other parts are covered with alluvial matter, to the depth of several feet, wherein are imbedded numberless limbs and trunks of trees. The greater part of this tract, having been cleared and drained, affords, in its higher portion, a rich soil of a sandy

loam, and in its lower portion, meadow lands of great value. The whole of it, being rendered available by means of drainage, for which it possesses sufficient fall, might become the most productive arable, and meadow land in this section of the country.

The other tract includes the Columbia, Whippany, Hanover, and Troy meadows, embracing an area of 10,000 or 15,000 acres. During the winter season the greater part of these lands are inundated; and these inundations frequently continue until so late a period in the spring, and even summer, that crops of great value are totally destroyed. But these inundations, in addition to rendering the lands entirely valueless, often leave large pools of stagnant water, which, under the influence of the summer sun, generate marsh effluvia, and, consequently, intermittent and remittent fevers.

The principal causes, both direct and indirect, of the frequent inundations of these lands are: 1st. The dike of trap rock at Little Falls, which intercepts the stream, and causes a back water for some distance. 2d. A bar formed (as far as examination has been made,) of sand, gravel, and boulders, (some of which are of gneiss, and from ten to fifteen feet in diameter,) at the Two Bridges, where this river receives the waters of the Pequannock. During the time of a heavy freshet, it is said that the back water extends up the Passaic a distance of eight or ten miles above the bar; and pieces of timber that have been seen floating down the Pequannock river, have been afterwards found ten miles above, in the Passaic. 3d. Bars are formed in the Passaic, near its junction with the Rockaway river, by the deposition of the sediment brought down by the Rockaway, Whippany, and Parsippany rivers. These sedimentary deposits, which are yearly increasing, together with an accumulation of a rapid and bountiful growth of plants, the two principal of which are, according to Prof. Cook, *Valisneria spiralis*, and *Potomogeton panciflorus*, choke up the passage, and cause the stream to become sluggish, and more liable to overflow its banks. During the last forty or

fifty years, the river has filled up to so great an extent, that lands, formerly dry and arable, are now inundated for a great portion of the year.*

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* It is evident that, if these lands should be thoroughly drained, they would become the most productive and valuable arable and meadow lands in this section of the State. Drainage would also have a tendency to render this whole district, and its vicinity, more healthy, by removing, in a great measure, the cause of the intermittent and remittent fevers, which prevail here, so generally, at certain seasons of the year. Little has yet been done for the accomplishment of this, although various plans have been proposed; and among them, the removal of the trap dike which intercepts the river at Little Falls, the removal of the bar at the Two Bridges, and the dredging out of the river, so as to remove the principal bars and obstructions. In 1834, Mr. R. B. Mason, civil engineer, was employed to make a survey of the river, from Chatham to Little Falls, and to report on the most feasible plan of draining the meadows bordering thereon. The report made by him was in substance as follows:

"*An account of fall in the Passaic River, from Baldwin's Bridge, above one mile north of Chatham, to Little Falls:*

	FEET.	INCHES.
From Baldwin's bridge to Dickerson Place	0	¼
" Dickerson's Place to New Turnpike	2	2
" New Turnpike to Cook's bridge	0	4
" Cook's bridge to Swinefield's bridge	0	3½
" Swinefield's bridge to Pine Brook	1	8
" Pine Brook to mouth of Deeparaal creek	6	9
" Deeparaal creek to reef of rocks	0	8
" Reef of rocks to top of Miller's dam	0	8
Whole fall, from Baldwin's bridge to top of Miller's dam,	12	1¾

This river, from Pine Brook to the mouth of Deeparaal creek, a short distance above Little Falls, pursues a very circuitous and winding course of near fifteen miles, with a fall of only five and a half inches to the mile, and with many abrupt and sudden bends—its banks constantly forming impediments to the rapidity of its current, or, in fact, almost destroying it, while in a direct course from Pine Brook to the mouth of Deeparaal creek, the distance is only three and three-quarter miles, with a fall of more than twenty-one inches to the mile, or nearly seven feet in the whole distance. If a canal or ditch should be opened from Pine Brook to the mouth of the said creek, to divert a part of the water of the Passaic from its present course, it would make a passage for the water, having nearly four times as

Tributaries of the Passaic.

Pequannock River.—This river rises in the Wawayanda mountain, and flows in a southeasterly direction, six miles to Morris County, whence, forming the boundary between Morris and Passaic Counties, it pursues a tortuous and rapid course through Stockholm, Newfoundland, Charlottenburgh and Bloomingdale, to Pompton Plains. Throughout the whole of this course it affords numerous and excellent mill sites, many of which are occupied for forges and other purposes. At Pompton, it receives the waters of the Ringwood and Ramapo rivers, the former of which rises in the State of New York, and flows through Passaic County, a distance of ten or twelve miles, in a southwesterly direction. From Pompton it proceeds, for the most part, with a sluggish current, through a level and undulating country, to the Two Bridges, at its junction with the Passaic river.

Rockaway River.—This river rises in the Wallkill mountains, in Sussex County; and thence pursuing a tortuous course through Russia and Milton to Petersburgh, it deflects to the southwest; and, keeping that direction to the line between Roxbury and Jefferson Townships, a distance of about nine miles, takes a southeasterly course to Dover, whence, in a northeasterly direction, it proceeds to Rockaway. From Rockaway, it flows in an easterly direction to Denville, where it resumes its northeasterly course to the distance of about one mile above Powerville. Here it turns towards the south-southeast, a di-

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much fall to the mile, with one-fourth of the distance to run; and, on account of the ditch being in a direct line, the nature of its banks would still less reduce the obstacles to be overcome by the curve. This would relieve thousands of acres, now covered with water for a great portion of the year, and would give valuable returns to their owners."

When the detailed topographical and geological survey shall have been completed, the most feasible plan for draining these meadows may be determined.

rection which it very nearly maintains to the Passaic river. Its whole length is about forty miles; and its course, except through Longwood and Berkshire valleys, is remarkably irregular. The principal sources whence this river derives its supply, are, Green Pond, Beach glenn and Den brooks, together with two streams about six miles in length, one emptying into it about a mile above Powerville, and the other about three miles below Boonton, and the Whippany river. Excellent water power is furnished along the greater part of its course, and, at numerous places, this power is employed in driving forges and other iron works.

Whippany River.—The Whippany river takes its origin in a number of small rivulets which find their way chiefly from the southeastern slope of the Trowbridge mountains, in Mendham, and Hanover Townships. These rivulets form two principal streams: which, after draining Watnong plains, and affording a number of excellent mill sites, unite at the head of Speedwell Lake, and thence flow in an east northeasterly direction through Morristown and Whippany, still furnishing the best facilities for manufacturing purposes. The single stream, which is thus produced, after passing through Whippany, crosses Columbia and Troy meadows, with a sluggish, almost imperceptible, current, and empties into the Rockaway river, about one mile above its junction with the Passaic. The numerous lakes and ponds formed in its course, give great variety to the scenery, and add much to the advantages of the surrounding country. Upon their banks and shores, numerous private residences may be seen, embellished equally by nature and art, and regarded as among the most charming and healthy residences in the Highlands. (See view of Speedwell Lake.)

Parsippany River.—This stream —a tributaryof the Whippany river—rises in the Trowbridge mountains, in Hanover Township, Morris County, and flows in a southeasterly direction, through the rich agricultural districts of Parsippany and Troy,

and thence, crossing the Troy meadows, empties into the Whippany river, one mile above its junction with the Rockaway river. This stream is ten miles long, and has a considerable fall from its source to the village of Troy. But, in addition to the Whippany and Parsippany rivers, which flow through the places bearing these names, as well as through Troy, there are numerous small tributaries, having their source in the continuous springs, bursting every where from the slopes of the hills, which not only afford admirable facilities for enriching the uplands and more elevated portions by irrigation, but which render the whole district one of the most noted in the State for grazing.

LAKES OF THE HIGHLANDS.

The Highlands of New Jersey are remarkable for a large number of beautiful lakes and ponds of fresh water, varying, in length, from one to five and a half miles. According to the plan of this report, no further description of them is attempted, however, at this time, than that which necessarily accompanies an enumeration of those most worthy of remark. They may be mentioned as follows:

1st. WAWAYANDA LAKE, situated upon the summit of Wawayanda mountain, about eight hundred feet above the level of the Wallkill river, and about one-third of a mile west of the Wawayanda Furnace.

This lake is about one mile and two-thirds in length; and is formed by the junction of two ponds, which have been made by the building of a dam near the "Furnace." The north northeasterly of these ponds is about two-thirds of a mile in length; the other, a little more than three-quarters of a mile in length; and the two are connected by a channel about one hundred yards wide, and one-quarter of a mile long. Their average width is about three-eighths of a mile; and both of them are contracted by a point of land jutting out from the eastern side. At their extremities, the water is quite shallow, but in some places it has

a depth of eighty feet. The supply is chiefly from two or three small streams, which have their origin in swamps upon the mountains; also from springs within the limits of the ponds themselves. The motive power employed at the Wawayanda Furnace, as well as at the mills located here, is furnished by these waters. Around them the hills rise to the height of fifteen to forty feet, with a slope varying from five to eighteen degrees; and while in some places the shores are rendered very rough by the outcropping of rock, in others they are comparatively smooth. Neither the shores, nor the hills, have yet been subjected to the hands of the cultivator, and they are still covered with a dense growth of different varieties of oak, together with chestnut, hickory, and various kinds of shrubs. The waters formerly abounded with Lake Salmon trout (Salmo confinis), weighing from six to eight pounds; large, yellow perch (Perca flaviscens), pickerel (Esox reticulatus), and other fish; but within the past few years, they have become less abundant.

2d. Hopatcong Lake, the largest in the State, and situated on Hopatcong mountain, between the counties of Morris and Passaic.

This lake is five and a half miles in length, and varies from one-third to one and three-quarter miles in width. It is the principal feeder of the Morris Canal, being at its summit level, an elevation of nine hundred and twenty-one feet above New York Bay, and seven hundred and sixty feet above the Delaware river at Easton. It is navigable for vessels of one hundred tons burden. In some places, its shores, formed of precipitous rocky bluffs, are very irregular; in others, long, narrow points of land stretch almost across it, forming numerous inlets and coves. It contains two islands—one towards its upper, or northwestern extremity, about one mile and a half in circumference, called Halsey Island; the other, formed of gravel and sand, about three-quarters of a mile in circumference, rising forty feet above

HOPATCONG LAKE.

its level, and called Canfield Island. It is fed by numerous small streams, which, originating in the springs of the surrounding mountain slopes, find their way to it through gullies, deep gorges and ravines. It abounds with fish; the principal of which are pickerel (Esox reticulatus), perch (Perca flaviscens), eels (Anguilla tenuirostris), cat fish (Pimelodus catus), which, at certain seasons of the year are taken in large numbers.

The accompanying cut presents a view of the lake from Tempys Point, looking towards the northwest. The characteristic features of the mountain ridges of the Highlands are pictured in the background; and the general formation and character of a Highland lake are very well exhibited by the low projecting points of the land, bluffs and mountain spurs, with their intervening coves, forming the banks, and surrounding Canfield Island.

3rd. Lake Senecawana, or Budd's Lake.—Situated in the central part of the Highlands, about six miles southwest of Lake Hopatcong, in Roxbury Township, Morris County.

This lake is celebrated as one of the most beautiful in the Highlands of New Jersey, and as occupying one of its healthiest localities. It is about three and a half miles in circumference, being supplied, chiefly, by the numerous rivulets formed from the springs of the gentle slopes surrounding it; and serving, itself, as one of the principal sources of the South Branch of the Raritan river. Its waters, remarkably clear, and well stocked with pickerel, (*Esox reticulatus,*) perch, (*Perca flaviscens,*) and various other kinds of fish, offer inducements to the lovers of piscatory sports, rarely found in any other section of the country.

4th. Greenwood Lake, or Long Pond—Situated partly in Passaic County, of this State, and partly in the adjoining State of New York. Its whole length is between seven and eight miles, of which, about three miles are within the territory of New Jer-

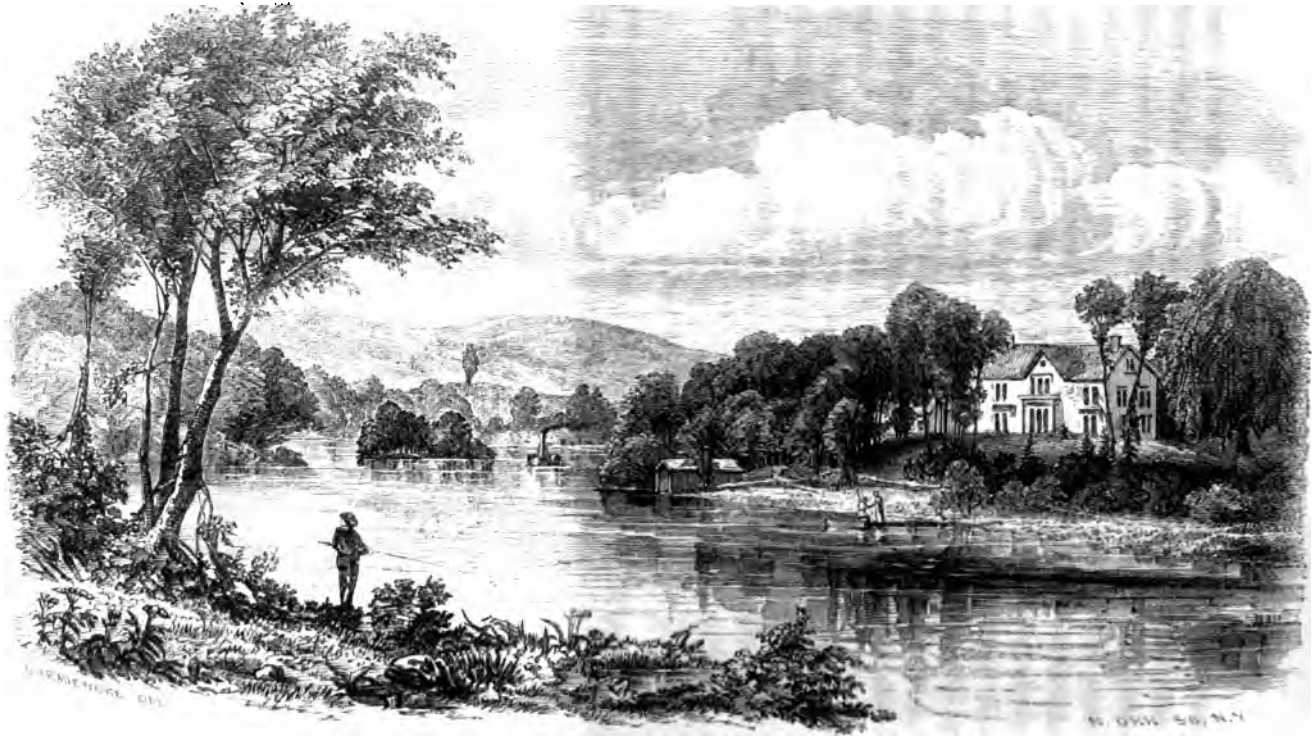
sey. Its width varies from one third to one half of a mile. Two parallel ranges of hills, varying from thirty to seventy-five feet in height, rise upon either side of it, with slopes of 10 deg. to 40 deg., and covered with trees, consisting principally of oak and chestnut. The depth of its water increases gradually from its southwestern to its northeastern extremity. The extreme southwestern portion was a swamp, until, by damming up its outlet, the water was made to rise. This outlet is from fifteen to thirty feet in width, and has quite a rapid current, while the streams flowing into the lake, with the exception of two, one of which is Belcher's creek, are very insignificant. This lake has long been a favorite resort for those who find pleasure in angling. Pickerel, (*Esox reticulatus*) and many other kinds of fish, are here found in great abundance.

5th. GREEN POND—Situated between the Green Pond and Copperas mountains, in Morris County.

This is a beautiful sheet of water, about two miles and three quarters in length, and from one quarter to two thirds of a mile in width. Its water, derived from springs quite near its border, is very clear and deep. Green Pond brook, its outlet, flows into the Rockaway river, near Washington Forge. On the northwest side, strata of conglomerate and sandstone rise, in the form of perpendicular bluffs, to the height of twenty, and sometimes forty feet. On the southeast side, the hills are comparatively smooth, sloping towards the water, at an angle varying from 10 deg. to 35 deg. The land in the vicinity, except at the northeastern end, where a portion is cultivated, is covered with a growth of chesnut, oak, and other trees, and underbrush. The pond abounds in pickerel, perch, and other fish.

6th. SPEEDWELL LAKE—Another beautiful sheet of water, lying in the course of the Whippany river, at the northwestern extremity of the Washington mountain.

This lake is about two miles in circuit, and is surrounded, in



CALDWELL LAKE

part, by gently inclining hills, whose slopes are covered with a luxuriant growth of oak, hickory, and chestnut. The cultivated lands in the vicinity are exceedingly fertile, and the banks furnish most admirable sites for private residences. The accompanying view is taken from the shore opposite to the dwelling of Hon. George Vail. In the background are seen the Trowbridge mountains, between which and the lake are the Watnong Plains. It will serve to illustrate the general character of the scenery bordering upon the lakes, ponds, and streams in this vicinity; the beauty of which, together with the healthfulness of the climate, and the facilities for communicating with New York city, render the district a desirable one for private residences. Already it is somewhat noted in this respect; and elegant and commodious mansions are beginning to stud the borders of the lake.

GEOLOGY.

The geological formation of the Highlands is chiefly comprised within that system of rocks, designated, at the present day, as the *azoic system*. This system is composed of sedimentary rocks, and is destitute of organic remains.

In that portion of the Highlands under consideration, the following varieties may be mentioned, as of most general occurrence, the reader being, at the same time, referred to the local details in this report, for their particular location.

1st. Gneiss.

2d. Hornblende, micaceous, feldspathic, and quartzose schists.

3d. White crystalline limestone, (saccharoidal marble,) interstratified with seams, or layers, of magnetic iron ore, (magnetite,) and iron pyrites.

T ese rocks, interstratified in various ways, occur in distinct belts, or mountain ranges, the slopes of which are, in some instances, flanked with palæozoic rocks. They are traversed by numerous intrusive dikes of granite and syenite, the general di-

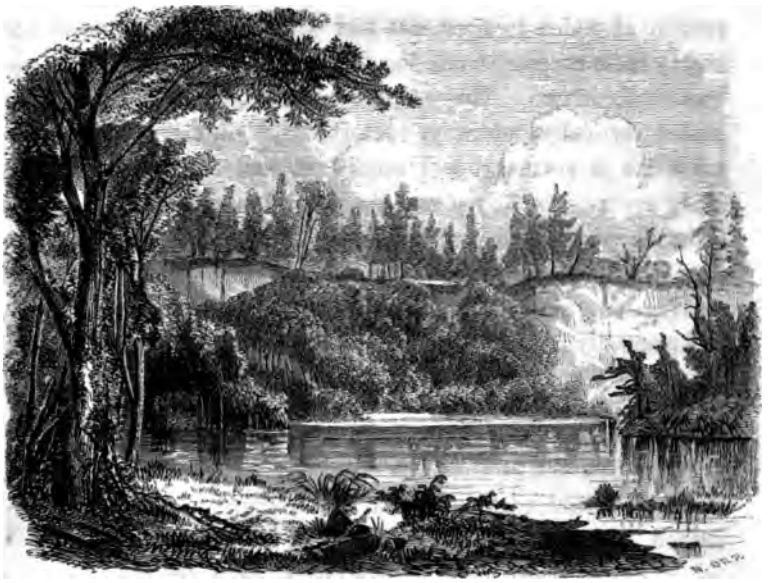
rection of which is northeast and southwest. The strata are highly metamorphic, rendering them crystalline, and subcrystalline in structure. They exhibit violent dislocations, being displaced vertically, laterally, contorted, folded, etc. Their general strike is northeast and southwest, and their dip southeast. They are traversed by joints, the general direction of which is at right angles to the line of strike. And in addition to their distinct stratification, and system of joints, they exhibit planes of cleavage frequently at right angles to the plane of stratification, and generally inclining towards the northeast, at an angle varying from the horizontal to 45 deg.

Micaceous (gneiss) Hornblende, Quartzose, and Feldspathic Schists.—These schists are composed chiefly of quartz, feldspar, hornblende, and mica, in various proportions, and arranged in laminæ. In some cases, one of these minerals forms the principal constituent of a stratum, or a series of strata; again, a stratum will be composed of two or more, in equal, or different proportions.

In addition to the above, the following may be mentioned as constituents of the rocks in particular districts and localities, viz: magnetic iron ore (magnetite), iron pyrites, phosphate of lime (apatite), epidote, graphite (plumbago), garnet, chlorite, and talc.

Magnetite is a very general constituent of these rock. In particular belts or localities, it occurs almost, or quite pure, in distinct strata, varying from an inch to forty feet in thickness. (For localities, etc., see local details of mines.)

White Crystalline Limestone.—This metamorphic rock is most extensively developed in the Vernon and Wallkill valleys, where it occurs in an almost uninterrupted belt, composed of a series of ridges, extending from the State line nearly to the headwaters of the Wallkill river. It is traversed by numerous dikes of granite and syenite, some of which may be traced, with



White Crystalline Limestone Bluff, near Franklin Furnace, Sussex Co.

Mine Hill, Franklin Furnace

but little interruption, for a distance of two miles. It is noted for its great variety of rare minerals, its deposits of red oxide of zinc, franklinite, limonite, and specular iron. In Byram Township it occurs in irregular masses, or isolated hills, apparently without any connection with each other. Near the line, between the townships of Sparta and Byram, it forms the broken ridge of two irregular hills, about one half a mile northwest of the origin of Wallkill river. Here it occupies a space of about one half a mile in length, and from one hundred to two hundred yards in width. There are other localities in Byram Township where this rock occurs, viz: about midway between Lockwood and Whitehall, upon the turnpike, where it covers, at the surface, an area of about three quarters of an acre. Again, on the east bank of the Cranberry Reservoir, upon the line of the Sussex Railroad, where it extends in a northeast and southwest direction, about one hundred and twenty-five yards, and from fifteen to twenty yards in width. Again, about three hundred yards west of Wright's Pond, it occupies, in a northerly course, a length of about one hundred yards. Also, near the dwelling of Mr. Samuel Smith, about one half a mile south of Stagg Pond, it covers an area of between three and four square rods. And, lastly, upon the land of Mr. Anthony Hemenover, and others, it extends in a northerly and southerly direction, a distance of five hundred and fifty yards, with a width of from eighty to one hundred feet.

LOCAL DETAILS.

Northwestern Boundary of the Azoic Rocks of the Highlands, from the New York State Line to Vienna, Warren County.

From the State line to Robert Owens' Island, a distance of two thirds of a mile, the azoic rocks of the northwestern base of Pochuck mountain, are bounded by the alluvial deposit of peat and muck of the Drowned Lands, which are here about one mile in width, between the exposed rocks and the Wallkill river.

Near the residence of Mr. Owen, and along the road leading

from Wallkill river, over Pochuck mountain, to North Vernon, these rocks take a wider range, and are exposed from the road, in a northwesterly direction, towards Owens' Island, the southeastern side of which is formed by a highly feldspathic syenitic gneiss, which is bounded by the limestone occupying the other portion of the island. The gneiss dips at an angle of 70 deg. to the southeast, its strike being N. 45 deg. E., by S. 45 deg. W. It contains numerous joints, having a direction S. 45 deg. E., and dipping at an angle of 80 deg. to the S. W. It is composed of feldspar, quartz, and hornblende. The feldspar is of a white color, sub-crystalline structure, and predominates over the other constituents. The quartz is of a dull grey color, and occurs chiefly in coarse grains, arranged in laminæ. The hornblende, which enters but very slightly into its composition, is of a pale green color, and is easily decomposed by the atmosphere.

The limestone rests uncomformably upon the gneiss, dipping at an angle of from 20 deg. to 25 deg. to the northwest. On crossing the island from the southeastern towards the northwestern side, the following varieties were observed:

1st. Gneiss of the above description, twenty feet in width.

2d. Limestone of a dirty blue color, and crystalline structure, thirty feet in thickness.

3d. Limestone of a dark blue color, containing more silica than the preceding; one hundred and twenty feet thick.

4th. Limestone of light blue color, containing a considerable quantity of silica in the form of small grains; sixty-five feet thick.

5th. Limestone of a bluish grey color, and of a compact structure, containing numerous seams of quartz, the direction of which is N. 45 deg. W. by S. 45 deg. E., dipping perpendicularly; one hundred and twenty feet thick.

6th. Limestone of a dark blue color, granular structure, highly silicious; (silica being finely disseminated through it in the form of small grains) and containing calcite in small white crystalline grains; one hundred and fifty feet thick.

From the southeastern side of Owen's Island, the exposed gneiss recedes to the road, leading along the northwestern base of Pochuck mountain, this road forming the boundary line between it and the overlying deposit of peat and muck. From the residence of Mr. Owen, in a southwesterly direction, for a distance of about one mile, the southeastern part of the alluvial deposits, from 200 to 500 yards in width, rests apparently, immediately upon the gneiss, while the portion near Mr. Owen's, between the Wallkill river and the mountain rests upon the blue limestone. On the turnpike leading across the Drowned Lands to Deckertown, blue limestone is again exposed, forming what is called Big, or Chandler's Island. It extends from the southeastern side of the island, where it disappears beneath deposits of muck and peat, in a northwesterly direction to the Wallkill river, and forms the steep and rugged banks of this stream, which vary from 15 to 85 feet in height. The strata dip at an angle of from 50 deg. to 65 deg. to the N. W.

On crossing Chandler's Island, from the southeast towards the northwest, several belts of limestone may be observed, which differ widely from each other, with respect to mineralogical and chemical composition. Across the Drowned Lands, towards Deckertown, the limestone is well exposed for examination on the northwest side of the turnpike, about two hundred and fifty yards N. 60 deg. E. of the house of Mr. Adam Quince. Its strike is N. 35 deg. E. by S. 35 W., dipping 68 deg. to the N. W. It is highly silicious, and contains, apparently, but little carbonate of magnesia. In it is occasionally found calcite of a yellowish white color, together with oolitic grains in irregular masses, some of which are one and a half inches in length, and one and a quarter inches in width. A series of narrow seams of quartz, from the thickness of a sheet of paper, to an eighth of an inch, traverse it in the following directions: N. 70 deg. W. by S. 70 deg. E.; N. 35 deg. E. by S. 35 deg. W., (coinciding with the strike of the strata); N. 45 deg. W. by S. 45 deg. E., (nearly at right angles to the line of strike.)

From the residence of Mr. Robert Owen, in a southwesterly direction, for a distance of nearly two miles, the road leading along the northwestern base of Pochuck mountain, forms the exact boundary line between the gneiss and granitic rocks, and the overlying alluvial deposits of the Drowned Lands. In several localities along this distance, granite and syenite form the very base of the northwestern slope of the mountain. The occurrence of granitic and syenitic rocks, forming the northwestern slope and base of this mountain, forms a striking contrast with its southeastern slope, where finely stratified gneiss almost universally prevails.

About two hundred yards north of the house of Mr. E. Martin, there occurs a granite composed of feldspar, quartz, and scales of both black and white mica. The feldspar, originally of a yellowish white and dull color, has decomposed into brown and flesh colors. The quartz is of a grey and dull color. It is traversed by numerous irregular joints, the more regular of which run N. by S.; N. 10 deg. W. by S. 10 deg. E.; N. 15 W. by S. 15 deg. E.; N. 20 deg. E. by S. 20 deg. W.; the system of joints in the last direction being the most regular.

About one and a half miles below Independence Corner, a short distance southwest of the road leading to Deckertown, blue limestone is again exposed, dipping at an angle of 40 deg. N. W., and resting upon the feldspathic gneiss of the lower part of the northwest slope of the mountain. From this point, in a southerly direction, for a distance of about one mile, the line between the gneiss and limestone is a little to the southeast from the road, between which and the Wallkill river, are numerous ridges and rounded hills of limestone. Thence turning to the east, until it is at a distance of about half a mile southeast of the Wallkill river, it follows in nearly a westerly direction, crossing the turnpike between Hamburg and Deckertown, at a point about three hundred and fifty yards southeast of the Wallkill river, and terminating at the southwestern extremity of Pochuck mountain, near the residence of Mr. Thomas Lawrence.

Following the boundary line from the termination of the mountain, the gneiss disappears, being overlaid by the limestone and drift, which form a series of hills, extending towards the southwest for a distance of more than two miles, with two exceptions, where it appears in the form of small knobs; one occurring about three-fourths of a mile from North Church (Hardiston village), near the road from that place to Hamburg, and the other, about three-fourths of a mile northwest of Franklin Furnace, at the side of the road leading from that place to North Church. It reappears a few hundred yards southwest of this locality, rising from beds of alluvion, which rest upon limestone and drift. In this vicinity its prevailing strike is N. 35 deg. E. by S. 35 deg. W., dipping in a southeasterly direction, at an angle varying from 65 deg. to 70 deg. This forms the northwestern termination of the Pimple Hill range. From this place it continues to approach, in its southwestern course, nearer to the road leading from North Church to Monroe Corner, being, at the line between Hardiston and Sparta Townships, at a distance of about a quarter of a mile southeast of Monroe Corner. The gneiss along this distance has the usual composition—feldspar, quartz, and mica.

The blue limestone resting on the northwestern slope of the hills of this range, with a strike of about N. 50 deg. E., and a dip of from 40 deg. to 50 deg. to the northwest, and unconformably upon the strata of gneiss, contains numerous small grains of quartz; and at many localities it partakes of a slaty character. From a point a little northeast of the Sparta and Hardiston line, in a southwesterly direction, deposits of drift intervene between the exposed gneiss and limestone; these, near Monroe Corner, are about two hundred yards in width, growing wider towards the southwest. Part of the drift rests upon limestone, and part immediately upon the gneiss.

From the Sparta and Hardiston line, the gneiss, for a distance of little more than a mile, continues in a southwesterly direction

to the grist-mill of Mr. James Smith, bounded all the way by drift, the boulders of which are chiefly of limestone and conglomerate. A few yards northeast of the grist-mill, a silicious limestone, of a bluish grey color, is seen resting uncomformably upon the strata of gneiss; the limestone dipping to the northwest, the gneiss at a steep angle to the southeast. About fifty yards west of the line between the gneiss and limestone, and northeast of the grist-mill, a highly ferruginous conglomerate is exposed, the exact thickness of which cannot be ascertained on account of the drift overlying it. From the grist-mill, the boundary of the gneiss, for a distance of about two hundred yards, coincides with the southeastern border of Smith's Pond. It then recedes from the pond, continuing its southwesterly course, and passing about two hundred yards southeast of Kimball's Pond. Thence it continues in the same direction, at a distance varying from three hundred yards to one-third of a mile northwest of the road leading from Monroe Corner to Pinkney's Corner, and crossing the road about three-quarters of a mile from Kimball's Pond, it continues nearly along with it for about one mile and a half. Along this whole distance, it is bounded partly by diluvial, and partly by alluvial deposits. At the few localities where it is well exposed, it has a dip of from 30 deg. to 35 deg. to the S. E.

About three quarters of a mile northeast of Pinkney's Corner, a belt of white metamorphic limestone, from a quarter to half a mile in width, bounds the gneiss for a distance of nearly one mile. It is generally of a highly crystalline structure, and very impure, on account of its admixture with other minerals, among which may be mentioned, spinel, chondrodite, mica, hornblende, scapolite, tourmaline, heavy spar, fluor spar, rutile, idocrase, etc., etc. Two dikes of granite, nearly parallel to each other, traverse it in a direction north-northeast by south-southwest. The western dike is nearly three hundred feet in width; and may be best examined in the vicinity of the house of Mr. John Case,

on the road leading from Pinkney's corner to Monroe Corner. This dike is composed of feldspar, quartz, and grains of magnetic iron ore. The feldspar is of a yellowish white color, and generally of a highly crystalline structure. The quartz is of a light grey color; not unfrequently these two minerals form large masses by themselves. The occurrence of grains of magnetic iron ore in this dike, is an exception to the usual composition, as most of those penetrating the limestone of Sussex County, contain none at all. Near the house of Mr. Joseph Current, and not far from the bend of the road, the northeastern continuation of the eastern dike caps the limestone, an occurrence which has been repeatedly observed within the belt of metamorphic limestone of the Vernon valley.

About two miles below Pinkney's Corner, where a branch road runs to the northeast, continuing thence, in a nearly southwesterly direction, for a distance of more than one mile, strata of blue limestone, much water-worn, are exposed, resting upon syenitic gneiss. Approaching the Andover Mine, the gneiss is bounded by the drift which forms the level lands in which Long Pond is situated. It is composed of both white and flesh-colored feldspar, light green hornblende, light smoky quartz, and yellowish and green epidote, which enters quite largely into its composition. The strike of the strata is from N. 20 deg. E. to N. 30 deg. E., dipping at an angle of from 60 deg. to 70 deg. to the southeast. From the low hills, at the south-southwest termination of the ridge, in a south, and southwest direction, the exposed gneiss recedes a considerable distance to the eastward of the road between the mine and Andover. Near the grist-mill at the latter place, sandstone and conglomerate of recent origin occur to some extent. About one hundred and fifty yards from this grist-mill, it may be examined in a hill which rises from thirty to sixty feet above the level of the meadows. It varies much in its composition, some parts being chiefly of quartz grains, while others are an admixture of almost every kind of rock occurring in Sussex

County, among which may be mentioned blue limestone, and dolomite of various shades and differing in structure; pebbles of white metamorphic limestone; slate, and calcareous sandstone, (similar in character to those occurring in Wantage Township;) different kinds of gneiss, syenite, and granite, varying in size from small grains to six inches in diameter, cemented together by carbonate of lime. On account of its rapid decomposition, it is difficult to ascertain its exact dip, which appears to be towards the west at a low angle.

Near Andover, limestone is not exposed in immediate contact with gneiss, deposits of drift intervening. On the line of the Sussex Railroad, near its junction with the branch road to Andover Mine, a series of limestone strata occur, varying in composition, structure, color, and general appearance. A section made at this place shows no less than fourteen different varieties within a distance of two hundred feet. Their strike is N. 20 deg. E. by S. 20 deg. W.; their dip 79 deg. N. 20 deg. W. They vary in thickness from one to four feet, interstratified with strata of shaly limestone, from a half to several inches in thickness. They have, generally, a compact, granular structure; very small grains of quartz enter more or less into the composition of some of them, rendering them somewhat soft and gritty. Some layers appear to be composed almost entirely of carbonate of lime, while others seem to contain carbonate of magnesia, in variable proportions.

From Andover in a southwesterly direction, the boundary line between the gneiss and limestone, cannot, for some distance, be distinctly defined, on account of the drift by which it is overlaid. Its general course is northeast and southwest. Further to the southwest, it corresponds in direction with the road leading from Andover towards Alamuche, Warren County. It is probable that blue limestone rests immediately upon the gneiss, but being partly overlaid by drift, this cannot be well ascertained. About three quarters of a mile southwest of Andover, and one

fourth of a mile southwest of the dwelling of Samuel Wilgus, deceased, a limestone occurs, of a light blue color, quite hard, and of a slightly crystalline structure. Its strike is about N. 30 deg. E.; its dip at an angle of 50 deg. in a direction about N. 70 deg. W. It continues in the direction of its strike, and crossing the road from Whitehall to Huntsville, about three hundred yards east of Mr. James Vansyckle's house, it passes along the western side of the pond known as "Decker's Pond."

West of the above described limestone, occurs another, of a darker blue color, interspersed with shades of grey. It is quite hard; breaks with an exceedingly uneven fracture; is of a slightly crystalline texture, and contains calcite, which fills its joints. Its strike is N. 25 deg. E., and its dip 65 deg. in a direction N. 65 deg. W.; the direction of its cleavage is N. 5 deg. E. by S. 5 deg. W.

Limestone is also exposed at the upper end of Green Township, about midway between the dwelling of Mr. John Vansyckle and Decker's Pond, where it is of a greyish blue color, of a compact and crystalline texture, breaking with a very uneven fracture, and apparently containing much silica. Its width is from fifteen to twenty feet. It dips at an angle of 60 deg. S. W., and its strike is about N. 45 deg. E.

Next to it, occur a few layers of calcareous sandstone, of bluish and brownish colors, of a granular texture, quite hard, and breaking with both a slightly conchoidal, and uneven fracture. It consists chiefly of rounded and water-worn grains, of variously shaded grey colored quartz, cemented by carbonate of lime.

On the southeastern side of Decker's Pond, occurs a series of limestones, having a strike N. 40 deg. E., and a dip at an angle of 45 deg. to the N. W. They are characterized by their hardness and compactness of structure; the varieties differing chiefly in the proportion of silica in them. One or two, however, are somewhat porous, and contain considerable calcite; another variety contains scales of mica. Forming a portion of this series,

are a few laminæ of a calcareous slate. Between these and the gneiss, occurs a bluish-grey limestone, with grains of quartz disseminated through it. It is but a few feet in thickness. Next to this, and bounding the gneiss, is metamorphic limestone, traversed by two or three dikes, the principal of which is a coarse aggregate of crystalline feldspar and rounded grains of quartz. This limestone is about one hundred yards in width, and its outcrop nearly half a mile in length. It differs much at various places, in regard to color, texture, quality, etc., being in some places white, and apparently free from all foreign substances; while in others, it contains many impurities, such as large grains of quartz of a dark grey color, mica in scales, chlorite, hornblende, plumbago, etc. There are portions which are but partially altered; the stone, in part, retaining its original color, but generally containing impurities. Other portions, still, are of a blue color, containing here and there a little calcite, in which there is considerable plumbago. In the parts which are but slightly altered, the texture ranges from compact to subcrystalline; and in those which are more completely changed, from subcrystalline to that which is highly crystalline: thus passing by regular gradations from ordinary blue limestone to that which is highly metamorphic.

The gneiss, near Decker's Pond, extends from twenty-five to one hundred yards northeast of the road from Andover to Tranquility, crossing it about half a mile below the pond.

The road, in its continuation to the county line between Sussex and Warren, and thence, through the village of Alamuche to Long Bridge, coincides very nearly with the boundary of gneiss. From this point to the county line, limestone, dipping to the N. W., rests upon the gneiss, although it is not exposed directly in contact with it, on account of an intervening belt of drift, which, in turn, is bounded by extensive alluvial deposits. Upon the drift alluded to, as well as upon the northwestern slope of the Alamuche mountains, are numerous large boulders of blue limestone.

From Long Bridge, it continues to a point opposite Vienna, the drift bounding nearly the whole of this distance. Where it does not bound it, the alluvial deposits, along the Pequest river, lie next to it. Within the limits above mentioned, the gneiss preserves its steep southeastern dip, with but one exception, viz., at a quarry owned by Nelson Cummings, at the road side, three miles and a half below Alamuche, where it dips to the N. W. at an angle of ten deg. At this locality, it is more or less coarsely granular, and is composed of quartz of a light grey and smoky color, with a vitreous lustre; feldspar of flesh, red and brown colors, and particles of magnetic iron ore arranged in layers. This is the first instance along this line where the gneiss has been observed to dip to the northwest. There are two systems of joints occurring in the gneiss of this locality—one extending in a direction N. 20 deg. E., by S. 25 deg. W., dipping at an angle of 80 deg., in a direction S. 30 deg. E., and the other at right angles to the first.

Southern Boundary of the Highlands, from the New York State Line to Morristown, Morris County.

From the State line, nearly to Pompton, a distance of about ten miles, the Ramapo river runs close to the southeastern boundary of the azoic rocks. Along this whole distance they are bounded by drift, and are in close proximity to large dikes of trap (melaphyre), some of which are within a few hundred yards of them.

About one mile northeast of the church at Pompten, the strata of gneiss occupy a vertical position; a short distance from which they are seen dipping to the northwest, at an angle of 80 deg., while, but a few yards to the southeast, they dip at the same angle in the opposite direction. The joints traversing them are at right angles to the line of strike. The rock, at this locality, is varied much by the proportion of its constituents; being, in some places, composed of yellowish-white feldspar, light colored

quartz, mica, and hornblende of a pale green color; in others, of feldspar and hornblende; and in others, again, of a finely granular admixture of quartz and feldspar.

The drift resting upon and bounding the gneiss along the course of the Ramapo river, forms a series of low hills, the more regular of which take a northerly and southerly direction. The boulders in the drift are of gneiss, granite, syenite, conglomerate and sandstone from the Green Pond Mountain, red sandstone, brownish, bluish and argillaceous sandstones, etc. As a general thing they are distributed very unevenly through the sand and gravel. There are, however, a few localities where there is a regular arrangement of the sand, gravel, pebbles, etc. About three-eighths of a mile N. 20 deg. E. of the Pompton Church, may be seen thin layers, composed of these materials, some of which dip to the south and some to the southeast, at low, but variable angles.

Near Pompton, the boundary line takes a turn northwest by west, passing above the church; and seven eighths of a mile west of the same it again bends, pursuing a southwesterly course. Resting upon this limit of the rock, is drift, of about the same character as that already described.

Two and a half miles from the last mentioned turn in the boundary line, and two and a quarter miles west of the Pequannock river, occurs, bounding the gneiss, a conglomerate, of alternating layers, of a coarsely and finely granular structure, dipping, at a slight angle, to the northwest. The lowest layers exposed, are composed of grains and small pebbles of quartz, of a dull grey color; soft, decomposed sandstone; compact feldspar; numerous scales of copper, and silver colored mica; scales of plumbago, etc. The grains of quartz and feldspar predominate, and are, for the most part, rough and angular. The upper layers, possessing a coarser structure, are composed of granite, gneiss, etc., rounded and smooth. The cementing material of both these varieties is the oxide of iron, to which their color, a reddish brown, is due.

From this locality, the gneiss continues in a southwesterly direction, keeping from one-eighth to three-eighths of a mile northwest of the road leading from Jacksonville to Beaver Dam Creek, the drift still bounding it for a distance of about two and a half miles southwest of the conglomerate above mentioned. At this place the gneiss comes in contact with trap (melaphyre), which continues with the line of the gneiss for a distance of about three hundred yards; this melaphyre is composed of labrador-feldspar and pyroxene; it is exceedingly hard, having a structure from finely granular to massive. It contains geodes of quartz, zeolites, etc.

The line of the gneiss continues on to the southwest, bounded by the drift, except at one locality, about three-eighths of a mile from the trap just spoken of, where conglomerate very similar to that already described, but of a little lighter color, occurs. From this locality, the line of the gneiss and syenite turns westward, and, as usual, is bounded by drift.

One mile northeast of Montville, a syenite occurs, composed of grey colored quartz, intimately mixed with compact feldspar of a pink color, and small particles of hornblende rapidly decomposing. In this rock, the quartz is the most abundant constituent; many irregular seams, of an admixture of feldspar and hornblende, run through it; and it is also traversed by numerous but irregular joints.

At Montville, at the roadside, near the inclined plane on the Morris Canal, again occurs a conglomerate, consisting of alternate coarse and fine layers, dipping at an angle of 10 deg. to the northwest. It is composed chiefly of quartz, flesh colored compact feldspar possessing a vitreous lustre, granulite of a rather fine texture, granite, gneiss, syenite, dark grey quartz, trap (melaphyre,) etc. These grains and pebbles vary in size, from that of a pin-head to more than an inch in diameter; they are cemented, as in the former case, by oxide of iron.

From Montville, the line between the exposed gneiss and drift

continues in a southwesterly direction, passing through Boonton, bounded the whole distance by the drift, the boulders of which show no regularity in their arrangement. From thence it continues nearly parallel with the line between the townships of Rockaway and Hanover, at a distance of from one to one and a half miles southeast of that line. The gneiss here is remarkable for rapid decomposition and disintegration.

At the line between the townships of Morris and Hanover, it bends towards the west; afterwards it takes a course nearly south, which it pursues for some distance, and then deflects to the east towards Morristown.

Enumeration and Local Details of Mines.

Observing the same order of arrangement in the enumeration of the mines and metalliferous deposits of this division, as was followed in enumerating the mountains and valleys, we begin with the most northwesterly metalliferous belt of the Highlands, which includes Pochuck, Pimple Hill, Andover, and Alamuche mountains, with the Vernon and Wallkill valleys.

In the Pochuck mountain, no metalliferous deposits, that are at the present time considered of economic value, have been found. The occurrence in the rocks of magnetic iron ore, and iron pyrites, in the form of grains disseminated through particular strata and in seams, bands, and bunches of very limited extent, have occasioned numerous openings in search of ore.

The Copperas Works, in Vernon Township, near Decker's Pond, is one of these. Here, iron pyrites constitutes the greater portion of a stratum of rock, which was worked some forty years ago to a considerable extent, for the purpose of manufacturing copperas from the ore.

The Pochuck mine, another, is situated about two and a half miles northeast of Hamburgh, and three quarters of a mile southwest of Smithville, immediately upon the line of the gneiss of the Pochuck mountain, and the white metamorphic limestone. This

mine was worked many years ago; and the ore was smelted at the Hamburgh Furnace. It is now owned by Col. Joseph Edsall. The ore is limonite (brown hematite), and occurs in the form of a very irregular deposit, which apparently is almost exhausted.

The Simpson Mine—still another, is situated about half a mile southeast of the dwelling of Mr. Robert Simpson, near Smithville. It was opened several years ago, and about eighty tons of ore taken out and smelted at the Hamburgh Furnace. The ore is specular, and occurs in a small deposit in the metamorphic limestone.

Between the Pochuck and Simpson mines and Hamburgh, boulders of limonite and specular ore are quite abundant.

From Hamburgh, in a southwesterly direction, no deposits of ore are met with, until near Franklin Furnace, where there are extensive deposits of Franklinite and magnetic iron ore, with more or less red oxide of zinc, in connection with the former; all of which have been worked.

About two miles southwest of Franklin Furnace, at Sterling Hill, there are two deposits of franklinite and red oxide of zinc, in the metamorphic limestone, near its junction with the gneiss of the Pimple Hill range.*

Following this range in a southwesterly direction, no deposits are met with until within one mile and a half of Andover, Newton Township, where the Tar mine is situated, and three-quarters of a mile further to the southwest, the Andover mine.

These mines are situated in a metalliferous ridge, which runs parallel to, and borders Long Pond. It is from one-eighth to one-fourth of a mile wide, and rises to the height of from one hundred and fifty to two hundred feet above the level of the water in the pond. The prevailing rock of this ridge is a dis-

* The above mines will be minutely described in the final report on the county of Sussex, now in course of preparation.

tinctly stratified gneiss, dipping at an angle of 70 deg. to 80 deg. to the southeast, and composed of feldspar, hornblende, mica, quartz, and frequently in admixture yellowish green epidote, red garnet, magnetite and iron pyrites, in crystals, grains and masses. The ore-bearing rock of this ridge is from twenty to one hundred feet wide, and for the most part consists of massive red garnet, iron pyrites, magnetite, epidote, calcite, dark green hornblende, feldspar and quartz. The garnet and iron pyrites predominate over the other constituents.

Tar Mine.—At this mine two large openings have been made; one about sixty feet long and seventy feet wide, and the other about one hundred feet long and ten feet wide. At the time of their examination they were both filled with water, which necessarily confined the examination of the mine to the surface, and to the rock which had been thrown out. The ore is chiefly an admixture of magnetite and iron pyrites, the latter constituting by far the greater part. Mr. Wurtz has mentioned the following minerals as occurring here. "Some specimens were selected from the rubbish lying around each of these openings, which comprise magnetite having regular cleavages, sometimes in regular octahedrons, generally associated with pyrites; green epidote in crystals, with calcite, having curved cleavages, in garnet rock, containing incrustations of calcite in fissures; and some others of less importance.

"Proceeding probably half a mile farther in a N. E. direction along the summit of the ridge, we come to Longcore's mine, where there are two more small abandoned openings on a seam of ore a few feet wide. The openings were both partially full of water, but it could not be seen that the seam of ore was highly pyritous. The northeasterly opening is upon a higher level than the other, and probably fifty yards distant from it. A considerable number of miscellaneous specimens were picked up at both openings, including the following:

"(1.) From the S. W. opening, pyrrhotine, mixed with

ANDOVER IRON MINE SUSSEX CO

pyrites; crystallized green epidote, with red garnet, pyrites, etc.; a transparent dark green feldspar, similar in appearance to that found at the Hurdtown apatite locality; seams and bunches of hornblende of the coccolite variety in red garnet; a greenish black hornblende in distinct prisms, several inches long. The pyrites of this mine, which occurs in large masses, and is sometimes crystallized in regular cubes, contains neither copper, nickel, manganese, nor zinc.

"(2.) From the N. E. opening, magnetic iron ore, possessing perfect crystalline cleavages, and polaric, mixed with much pyrites; a feldspar rock containing much greenish white and yellow epidote; a granular garnet rock, containing seams of white and green feldspar, yellow epidote, and quartz; mixtures of black hornblende, white and green feldspar, etc."

Andover Mine.—Mr. Wurtz has described this mine, together with the minerals occurring in its vicinity, as follows: "The ore-bed here is imbedded in the same kind of rock as the ordinary magnetic iron ore seams of this region, and bears a general resemblance to them also in configuration and structure, the longer axis of the mass of ore lying in a direction from N. E. to S. W., or parallel to the strata of the gneiss rocks of this country, and the walls of the ore-bed, wherever they are well defined, being vertical, or nearly so; but the ore itself is, for the most part, quite different in its nature, approaching generally more nearly to the constitution of hematite, or red oxide of iron, a substance which differs from magnetite or the black oxide, only in containing more oxygen. These ores generally contain, moreover, a much greater proportion of manganese and zinc than the magnetic ores, and usually quantities of these metals which must exert an important influence upon the quality of the iron made from it. There are also associated with this ore bed, in various places, quantities more or less great of minerals containing lead, copper, zinc and manganese, which are not found at the other mines; so that this mine, while it may be considered as belonging to the same *family* of mineral formations as the magnetic ore seams

which have been described, must be admitted to be of a different *species*.

"In addition to the facts given with regard to this mine, in the Report of the Survey of 1854, page 39, I am enabled to give the following additional information, acknowledging first my indebtedness for the numbers and measurements given, to Mr. Richard George, the Superintendent of the mine.

"The open excavation, which has been made along the course of the ore deposit, from N. E. to S. W., is seven hundred and fifty feet in length, and from thirty to sixty feet or more in width, and very variable in depth. At the S. W. end, the depth of the deposit appears usually to have been small, although in places it increases to perhaps thirty or forty feet, forming what may be called basins or bowls, formerly filled with ore. There are two or three of these basins, in the southwestern portion of the mine, the ore of which has been entirely worked out. Proceeding towards the N. W., we find another basin of very great size, several hundred feet in length, and eighty-five feet in depth, where the deposit expands to an average width of sixty-five feet, its maximum width being as much as seventy-five feet. In this part of the mine also the ore has been mostly worked out, leaving a vast pit, the side walls of which are generally vertical, and the bottom very uneven and irregular. To convey any distinct idea of this excavation by words, without the assistance of drawings, would be impossible, so that I shall confine myself at present to a few special observations.

"In the bottom of this excavation there are two principal bowl-shaped cavities, with a ridge of rock rising between them, the longitudinal direction of which is the same as that of the whole mine. The cavity on the S. E. side of this ridge is much the deepest, and the S. E. wall of the ore-bed, or the hanging wall, as it is called, and as it actually becomes, farther to the N. E., in what is called the middle slopes, where the ore-bed assumes a steep dip to the S. E., presents the appearance of a perpen-

dicular precipice, eighty-five feet high at the highest place, and two or three hundred feet in length. Upon the wall is perceived an appearance similar to that described as occurring upon the foot wall at the entrance to the Mount Hope Open Workings, namely, a marking or furrowing of the face of the rock, the furrows being, however, in this case, unlike those at Mount Hope, very irregular and ill-defined. These furrows, like those at Mount Hope, dip towards the N. E., though at a somewhat greater angle, which in this case may amount, according to my best recollection, no measurement having been made, to about 15 deg. from the horizontal. The degree of this inclination may be of importance to the comprehension of the form of those parts of the ore bed, which have not yet been opened, lying to the N. E., where the upper boundary or limit of the ore bed sinks below the surface of the rock. Some of the furrows visible on the hanging wall, are filled with a pulverulent hydrated sesquioxide of manganese.

"The immense mass of ore which has been taken out of the great basin above described, had a peculiar structure. There are two principal varieties of ores found, known to the miners by the names of "blue ore" and "red ore," of which full descriptions will be given hereafter. The mass of the ore-bed presents the general structure of a kernel of the blue ore, surrounded by a thick shell of the red ore. Thus, on the top, the ore is found to be of the red variety, and the same next to the two walls, and the bottom of the deposit, while the centre is usually of the blue variety.

"Passing on to the N. E., from the great basin, we come to the middle stopes, where the miners were at work at the time of my visit. It is about here that the railroad upon which ore is taken to the Morris canal at Waterloo, seven miles distant, enters the mine. Upon this railroad there were being run, at the time of my visit, five ore-trains per day, carrying each fifty tons of ore. The workings at the middle stopes have reached to some twenty-

five or thirty feet below the level of the railroad, and at this point the ore bed is much narrower than usual. Passing onward to the N. E., the workings are no longer open to the sky, but are entered by means of drifts and shafts. They extend about two hundred feet beyond the middle stopes, making the whole distance throughout which this ore deposit has been opened, nearly one thousand feet. In the extreme N. E. workings, the width of the ore averages about thirty feet, and the lowest point, or deepest part of the whole mine, is fifty feet below the railroad. The ore in the N. E. stopes approaches more to the condition of magnetite, being in some places identical in appearance with some of the ores of the ordinary magnetic iron seams in Morris County, as will be seen from the descriptions of the specimens given below.

"Some superficial excavations have been made to the N. E. of the mine, and lead and copper minerals found. In one place has been thrown out a considerable quantity of galena, and at another some materials containing malachite and copper pyrites, but from the indications observed, there is small reason for expecting to find these minerals in regular veins, or in any form sufficiently reliable to justify mining operations.

"Some two hundred yards or more to the N. E., nearly or quite in a line with the great ore bed, appears another opening, made into a seam of ore of some size, which crops out on the steep slope of a hill. The materials thrown out appear to be principally mixtures of magnetite with a great deal of pyrites. Near the surface considerable galena appears in bunches. Specimens were collected at this spot.

"Proceeding on farther in the same direction, many more superficial indications appear of the presence of different varieties of iron ores, the whole vicinity appearing to be highly metalliferous, and to merit a much more thorough exploration.

"Mr. George states that during the time that he has been in superintendence of the mine, now about eight years, more than

120,000 tons of ore have been sent away, and at the time of my visit, there were about 3,500 tons lying at the mine awaiting removal. There were seventy men employed at the mine during the last summer; the greatest number ever employed at any one time being ninety-eight, in the month of November, 1854. The ore all goes to the furnaces of the Trenton Iron Company (who are the proprietors of the mine), near Easton, and is there used, in combination with other ores, in the making of the pig iron, which is now being puddled and manufactured into wrought iron beams for buildings, at the works of the Company at Trenton. In this connection, I may state that at my request, Mr. Charles Hewitt, the Superintendent of the Iron Works referred to, has had the kindness to procure for me authentic suites of specimens, illustrating every step in the processes of the manufacture of iron from the ore of the Andover mine, a portion of the ore having been taken specially for the purpose, and followed through the whole operation, reserving samples of the results of each step.

"The specimens are as follows:

1. Andover ore.
2. The limestone used as flux.
3. The pig iron, made at Easton.
4. The slag from the blast furnace.
5. The puddled iron, made at Trenton.
6. The puddling furnace cinder.
7. The reheated iron.
8. The heating furnace cinder.
9. The finished iron.

"They are all of large size, and besides being ornaments to the State Cabinet, and in the highest degree valuable and instructive, as illustrating in the most palpable and practical manner, the subject of the iron manufacture, they will furnish me an important opportunity to investigate the process chemically, by making analyses of the various samples, a comparison of

which will throw new light upon the changes and reactions which take place, and furnish data upon which to base improvements. Thus Mr. Hewitt has placed the community, as well as myself, under obligation.

"A very large collection, comprising some hundreds of specimens, was made at Andover, in order to represent not only the kinds of ore from different parts of the mine and their associated rocks, but also the great variety of interesting minerals which are found in profusion in and about the mine. Some of the specimens collected are of large size, and several of them may be pronounced to be among the most remarkable and interesting of their kind. In describing the specimens I will commence with those from the most southwesterly portion of the excavation, and proceed towards the N. E., considering the miscellaneous specimens last.

"(1.) Ore from a basin or cavity, situated at the S. W. extremity of the mine, which is a mass of nodules of red and black hematite, of irregular forms and sizes, cemented together, and containing much crystalline yellow blende (sulphide of zinc.)

"(2.) Ore from another basin lying intermediate between the above and the great basin, and situated upon the highest part of the hill, which is composed of small, hard, compact granules of the black hematite, cemented by the red hematite, which is silicious and somewhat jaspery in appearance in some places. These two varieties of hematite, which make up the great mass of the ore throughout the greater part of the whole bed, require special description. The red mineral consists essentially of red oxide of iron, most usually, if not always, mixed in the most intimate manner possible with more or less silica, so that the mass possesses sometimes the fracture and lustre of quartz, although having also the red color of hematite; and sometimes the silica appears to be wholly or partially in the amorphous or opaline condition, and the mass has a jaspery fracture, forming, when

the color is bright, as it frequently is, very pretty specimens of red jasper. The black mineral, which forms the greater portion of the centre of the mass of the ore-bed, as before stated, and is called 'blue ore' by the miners, from a bluish tinge which it has, appears to differ from the red mineral principally in containing more or less manganese, in the form of sesquioxide or deutoxide, or both, and to this admixture its color is probably in some cases due; although, from the fact that it is usually attracted to some extent by the magnet, it may contain a small quantity of magnetite; but still it is difficult to imagine how magnetite can exist in the presence of any of the higher oxides of manganese, supposing this ore-bed to be of igneous formation, or to have ever been subjected to the action of a heat sufficient to fuse or semifuse its contents. Here then is a point, which when settled by the investigations which I now have in progress, must throw some light upon the nature of the agencies concerned in the formation of this mass of ore. It must be remembered that, according to the investigations of Delesse,* hematite ore is sometimes magnetic, its maximum attractibility being represented by the number 2.35, that of steel being 100, and that of magnetite ranging from 15 to 65. It is possible therefore that the magnetic force of the Andover mineral may be due to the sesquioxide of iron which it contains as its predominating ingredient, although in my opinion it is frequently too well marked to be attributed to anything but an admixture of magnetic oxide. There is a difficulty in determining the condition of oxidation of the iron in a mineral like this, which contains one of the higher oxides of manganese, as on solution in an acid the iron is inevitably sesquioxidized by the oxide of manganese. In view of the peculiar composition of this black mineral, I have been at a loss by what name to designate it, as it must be frequently spoken of in this report; but I have finally concluded to call it 'black hematite,' because it is essentially hematite, and derives its dark tinge

* See Dana's Mineralogy, 1854, I, 176.

merely from some admixture, whether this be magnetite or one of the oxides of manganese, or both. I must remark, however, that I do not intend to compare it with the doubtful species psilomelane, which, as I should have remarked before, it sometimes resembles very much in appearance, and to which the name 'black hematite' has also been applied.

"The so-called 'red ore' of the mine, is a mixture in very variable proportions of the black hematite with the red hematite, the latter usually predominating, and forming sometimes, apparently, the cementing material which binds together the nodules or granules of black hematite. All the ores of this mine are excessively hard, and strike fire with steel, owing to the silica which they contain.

"(3.) Specimens from the mass of ore formerly existing in the great basin.

"(*a.*) Two varieties of ore, which were found in the upper part of the bed near its surface, the first of which is composed of cemented nodules of black hematite, irregular in size and shape, and distinctly attractable by the magnet, containing also much calcite in small seams and disseminated; while the second is a pulverulent mixture of granules of the black hematite with amorphous red hematite.

"(*b.*) Ore from the southeast side of the bed next to the hanging wall, which is 'red ore,' or a mixture of the black and red hematites, the latter predominating, and possessing the jaspery or subvitreous fracture usual to it. It contains numerous seams of calcite.

"(*c.*) Rock from a 'horse,' or small seam, which pervaded the ore-bed not far from the hanging wall, and parallel to the latter, which is a schist composed principally of a dark colored mica, with fissures lined with incrustations of calcite, which are sometimes columnar in structure.

"(*d.*) 'Blue ore,' from the central portion of the bed, which is hard, heavy, black, and nearly or quite amorphous, with a

brilliant lustre on the surfaces of fracture, magnetic to an important degree, and even polaric. It is full of brown garnet and honey-yellow blende in particles, laminated in its structure, and penetrated in every direction by small seams of white calcite.

"(*e.*) Ore from the northwest side of the bed, next to the foot wall, which is precisely similar to (*b*) the ore from the southeast side.

"(*f.*) Ore from the same side as (*e*), but from the bottom of a basin which exists there, which is apparently identical with (*e*) and with (*b.*)

"(4.) Ore from the middle stopes, where the ore-bed descends under the rock. In this part of the mine, the red variety of the ore decreases and entirely disappears, the whole mass being of the blue kind. There were collected specimens of several different varieties of the blue ore, which differ principally in their structure and mode of aggregation, and not much in their composition; some being granular; and others compact, with a black, jasper-like fracture and lustre, and having a large jointed cleavage; together with all the gradations between these two extremes. All are more or less magnetic, but the attractibility is confined to particles diffused more or less abundantly throughout the mass, of which some specimens contain but few.

"(6.) Miscellaneous specimens.

"(*a.*) Garnets, with willemite, etc. This garnet occurs in crystals, probably as large as any found in the world; one which I have, although broken, retaining several of its faces in perfect condition, which show by their size that the whole crystal must have been at least six inches in diameter. Others are very plentiful, from the diameter of half an inch up to two or even three inches. The smaller crystals sometimes retain considerable polish, but the larger ones are dull, apparently from the effect of alteration. They are rhombic dodecahedrons, and in some of the larger specimens, the edges are truncated. The color of this garnet is chocolate brown, and it is generally opaque,

and fragile from the effect of alteration. From the frequent association with it of willemite, or silicate of zinc, and of hydrated sesquioxide of manganese in fine powder, filling cavities, and from its apparently considerable weight, it is suspected to be highly manganiferous, or zinciferous, or both, and an analysis will be made to determine the point. The specimens of garnet collected, include masses a foot or more in diameter, covered with crystals of various sizes, and forming exceedingly fine specimens. The willemite, which occurs in hexagonal prisms, generally of a greyish color, but sometimes nearly white, among the garnet crystals, is a very rare mineral species, of which I can find but one known European locality, and but two others on this side of the Atlantic, both of which are in New Jersey, namely, Mine Hill and Stirling Hill, in Sussex.

"(*b.*) Calcite, or carbonate of lime, in a great variety of forms; such as seams of a white color pervading nearly all the other materials of the mine and masses of crystals, of white and beautiful salmon colors. Associated with masses of calcite of the latter color, were found irregularly, but very sharply angular, nodules of the bright red jasperoid hematite, imbedded in black hematite, presenting a very singular appearance. Sometimes calcite of a white color occurs together with the black and red hematites, in alternate narrow bands, presenting a striped, agate-like appearance, and these bands or laminæ will be crossed again at various angles by seams of white calcite or quartz. The crystals of calcite sometimes present the pearly lustre and curved surfaces of dolomite, but contain no magnesia. The surfaces of the crystals are sometimes striated parallel to the lateral axes of the rhombohedron. Masses and seams of calcite occur, having these curved and striated cleavages an inch or two across; such seams were found enclosed by surfaces of crystalline red hematite, having a mamillary aspect. Calcite also occurs in the form of a great variety of incrustations upon the ore and upon the rocks, showing every gradation of beauty and delicacy, some amorphous,

some mamillary, some botryoidal, some crystalline, and some in the form of dog-tooth spar, together with another very beautiful one, consisting of a congeries of very flat rhombohedrons, almost thin enough to be called plates. None of these various incrustations contain any magnesia, but several of them contain much zinc, especially the one last spoken of, which probably owes its peculiar form to the presence of zinc. Indications were encountered which seem to prove that the process of formation of these incrustations is now, or has been at some recent period, going on, as heaps of fragments apparently of artificial formation, were found incrusted, and even cemented together.

"(*c.*) Blende or sulphide of zinc in crystals, sometimes black, and sometimes transparent and of a beautiful honey-yellow color, the former variety associated with malachite and drusy quartz, and the latter in masses of angular fragments of hematite cemented together by calcite.

"(*d.*) Fluor spar, of a dark violet color generally opaque and massive, but sometimes transparent and giving indications of an octahedral cleavage, imbedded in quartz and associated with calcite. Besides the mineralogical agreement of this mineral with fluor spar, chemical examination proved it to be that species, and deep etchings were produced on glass by its means. Before the blowpipe, previous to fusion, the mineral loses its violet color completely, becoming pure white and opaque.

"(*e.*) Galena or sulphide of lead is principally found at points N. E. of the large mine, and will be spoken of again below.

"(*f.*) Chalcopyrite or copper pyrites occurs in patches diffused through masses of calcite, which have large curved and striated cleavages.

"(*g.*) Malachite or green carbonate of copper generally amorphous, associated with amorphous hematite, and drusy quartz; sometimes also with a black pulverulent substance, which is cupriferous, and is either oxide or sulphide of copper, or a mixture of both; also occasional patches of azurite.

"(*h.*) Magnetite is found occasionally in regular octahedral crystals.

"(*i.*) Talc of a beautiful green color and very pure is found quite abundantly in many parts of the mine, sometimes in a white opaque calcite, and red jasper, making specimens of a striking aspect, from the contrast of color.

"(*k.*) Mica (phlogopite?) of a black color, and perfectly opaque, in plates sometimes an inch in diameter, in large masses of a singular appearance, the cleavages of the mica not lying parallel, but arranged in all planes, in a very disorderlym anner; sometimes mixed with an amber-colored garnet.

"Other miscellaneous specimens are various singular mixtures and conglomerates of the various minerals found in the mine; including masses of very irregular nodules of hematite, sometimes crystalline, sometimes amorphous and angular in shape, cemented together by calcite, and having thick incrustations of finely laminated hematite; the calcite is frequently interspersed with crystals of honey-yellow transparent blende. Some of the large angular nodules of hematite in these heterogeneous mixtures are themselves finely laminated, and evidently fragments of former incrustations, which have been broken into pieces by some convulsion, and afterwards re-cemented. These form very beautiful and useful specimens for illustration.

"Masses of hematite were found containing cavities lined with drusy quartz, and containing a mineral in small, long, flat, thin, transparent prisms, arranged in groups radiating from centres. These crystals were too small to be measured, but under the magnifier appeared to be of the monoclinic system, or possibly hemihedral forms of the trimetric system. Their chemical composition makes them a hydrated silicate of zinc, so that they are most probably calamine, which is trimetric. This mineral will be analyzed.

"(7.) Specimens from the shallow excavations N. E. of the great mine. These include masses of limonite, containing amor-

phous malachite and azurite; pulverulent limonite in very large masses; malachite incrustations on jasperoid hematite; massive pyrites, honey-combed by oxidation; a red rock, composed of an intimate mixture of finely granular hematite and calcite; various singular looking mixtures of calcite, hematite, and chalcopyrite, presenting a spotted leopard-skin-like appearance in fracture.

"Here, also, is found galena in some abundance. It is generally finely granular and incrusted, and mixed with a yellowish pulverulent substance, which is a carbonate, and therefore probably amorphous cerusite. It contains no appreciable quantity of silver.

"(8.) Specimens from the opening on the hill-side N. W. of the mine, mixtures of magnetite, cupriferous pyrites, and wine-red garnet in crystals, which form the mass of the seam of ore, sometimes in admixture with calcite, a little chalcopyrite and green hornblende. These minerals are mixed together in all proportions, and some specimens contain principally magnetite, to the exclusion of the others.

"The cupriferous pyrites above spoken of, which is found quite abundantly, is not chalcopyrite, as it is lighter in color, harder, (although not equal in this respect to common pyrites,) and contains much less copper. It tarnishes to bronze and irised tints. It much resembles in character the supposed peculiar cupriferous pyrites, observed at the Mount Hope Tunnel, associated with the supposed new titaniferous mineral found there. An analysis will be made to ascertain both its nature and whether it is worthy of exploitation, for the copper it contains.

"Other specimens found at this spot are terminated prismatic crystals of hornblende, the faces of which were, however, much altered and roughened, (I ∶ I with the common goniometer=123½ deg.; hornblende is 124½ deg.) associated with apatite in green prisms, and crystallized calcite, in a granular crystalline garnet

rock; a very curious rock, composed of crystalline calcite, with numerous irregularly shaped granules of a dark green mineral, resembling serpentine, patches of chalcopyrite, and some green transparent crystals of apatite interspersed through it. The galena which occurs here, is in considerable quantity, presents cleavages of some size, and is imbedded in garnet rock.

"It will be interesting to give here in recapitulation, a list of all the minerals found at the Andover mine, and in the immediate vicinity, including three or four found at the Tar and Longcore mines.

"Garnet, crystals sometimes several inches in diameter, of chocolate-brown, amber-yellow, and wine-red colors.

Willemite, in hexagonal prisms, some nearly white in color.

Earthy manganese, (hydrated sesquioxide ?)

Calcite, opaque, white and salmon-colored crystalline, striated, and with curved cleavage surfaces, also as dog tooth spar, and varieties of mammillary incrustations, also zinciferous calcite, in very much flattened rhombohedrons.

Blende, opaque, black, and transparent honey-yellow.

Fluor spar, of dark violet color.

Galena, cleavable, and granular.

Cerusite (?) amorphous.

Chalcopyrite.

Malachite, amorphous.

Azurite, in incrustations.

Quartz, drusy, and other forms, such as jasper.

Magnetite, massive and in regular octahedrons.

Talc, pure, and of green color.

Mica, black opaque.

Hematite, crystallized, and amorphous.

Calamine (?) in small transparent prisms.

Limonite, massive, and pulverulent.

Pyrites, in numerous forms.

Hornblende, in crystals; variety coccolite at Longcore's mine.

Apatite, in transparent green prisms.

Epidote, in green crystals, at Tar Hill mine, and elsewhere, and of yellow color at Longcore's mine.

Pyrrhotine, at Longcore's mine.

Feldspar, translucent green, at Longcore's mine."

CHAPIN MINE.—The next and last in this range, in Sussex County, is a mine in Green Township, near Decker's Pond, which was opened by Mr. Daniel Chapin, of Sparta, and afterwards owned and worked by the Glendon Iron Company. The deposit is of magnetic iron ore, and occurs at the junction of the metamorphic limestone and gneiss. The ore contains a large proportion of pyrites and hornblende.

Several openings have been made for iron ore upon the Alamuche mountains, but at none of these, except the Brookfield mine, has it been found in any considerable quantities.

The BROOKFIELD MINE is situated about one mile and a half southeast of the village of Alamuche. It has been worked but a few feet from the surface, and is now filled with water. The seam of ore is from three to five feet in thickness, and is divided by a layer of rock, ("horse,") from one to two feet in thickness. The ore is highly magnetic, and contains, in places, a small proportion of pyrites. It is considered an excellent forge ore.

Mines of the Wawayanda, Wallkill, Hopatcong, and Schooley's Mountain range.

The WAWAYANDA MINE is situated upon the Wawayanda mountain, in Vernon Township, Sussex County, about three-eighths of a mile southwest of the State line. At this place, there are five deposits of magnetic iron ore, four of which are worked the present time, furnishing the ore smelted at the Wawayanda Furnace.

About one-quarter of a mile farther to the southwest, on the land of Mr. J. S. Green, small openings have been made upon three deposits of ore.

The WILLIAMS MINE, situated about three miles south of the village of Vernon, is the next upon this range. The ore here is magnetic. Twenty or twenty-five years ago, it was very extensively worked; but since that time it has been abandoned. The rock, both upon the northwest and southeast side of Canisteer pond, contains much magnetic iron ore, in grains and small masses. Many have been led to make fruitless search for larger deposits in this section.

About three and a half miles west of Canisteer Pond, and two miles northeast of Upper Hamburgh, near the northwestern boundary of the Wallkill mountain, a bed, or deposit of limonite, (brown hematite,) occurs in ferruginous gneiss. It was worked for a number of years, and the ore was used at the Hamburgh Furnace. This is called the EDSALL MINE.

The OGDEN MINE is situated in the Wallkill mountains, in Sparta Township, three miles southeast of Franklin Furnace. The deposit of ore is from two to thirty feet in thickness, and has been worked to a depth of forty or fifty feet.

The VULCAN MINE, one-half mile southeast of the Ogden mine, has been worked in two different deposits of ore; one nine feet, and the other ten feet in thickness.

The SHERMAN MINE is situated three-quarters of a mile southeast of Sparta, on Slack brook. Several openings have been made, exposing the ore from three to ten feet in thickness.*

In this range of mountains in Jefferson Township, Morris Co., are the following mines, viz:

The FORD and SCOFIELD MINES, situated between three and four miles E. N. E. of Woodport. They are both in the same deposit, consisting of magnetic iron ore, varying from three to twelve feet in thickness. The Scofield mine has been worked to a depth of forty feet, and the Ford to the depth of one hundred

* For a description of the above names, see First Annual Report on the Geological Survey of New Jersey.

and four feet. The ore is finely granular, and very compact, containing in admixture iron pyrites, hornblende, and rounded grains of apatite.

The WELDON MINE is situated on Weldon brook, two and a quarter miles east of Woodport. The deposit of ore crops out for more than half a mile on the northeastern declivity of a ridge. Numerous openings have been made into it, exposing the ore-bearing stratum from three to five feet in thickness. It is composed chiefly of magnetite, feldspar, quartz, and hornblende; in some places irregularly mixed together in about equal proportions; and in other places seams of pure magnetite, from a half to two inches in thickness, alternating with seams or laminæ of rock.

The DUFFEE MINE, about two miles northeast of Woodport. The deposit of ore is from two to four feet in thickness, and contains a large quantity of feldspar, quartz, hornblende and epidote, in admixture. This last mineral enters largely into the composition of the wall rocks.

The HURDTOWN MINE, situated about one and a quarter miles S. S. E. of Woodport; and the HURDTOWN APATITE MINE, situated one-quarter of a mile W. S. W. of the Hurdtown Forge. Mr. Wurtz describes these two localities as follows:

"We pass over to the neighborhood of Hurdtown, near the head of Lake Hopatcong. Here is a large iron mine, formerly extensively worked, but not now in operation, and therefore inaccessible for the most part. Judging from the excavation made, the bed of ore must have been, in one place at least, from thirty to forty feet in width. The strike and dip are the same as usual. Specimens were collected of the ore, from masses lying outside the mine, and a number of miscellaneous specimens picked up from the heaps of rubbish.

"The ore specimens found present various appearances; some heavy, hard and granular, sometimes exhibiting distinct cleavages; some containing considerable apatite, others a little horn-

blende; some is 'shot ore;' some specimens are jointed, the faces produced by the joints being coated with films of pyrites.

"The miscellaneous specimens include a great variety of mamillary incrustations of wax-yellow and cream-yellow chalcedony in fissures in magnetic iron, some of which are very beautiful; sometimes a lenticular mass of magnetite is enclosed in laminated chalcedony, and partakes itself of the laminated structure of the latter, while similar masses of chalcedony are in like manner enclosed in laminated magnetite.

"Other specimens are masses of translucent quartz, containing seams and strings of magnetite; mixtures of large crystals of magnetite and pyrites in feldspathic gneiss; masses of nearly pure black hornblende; magnetite with a coarse crystalline structure, and many of the faces of the crystals coated with thin folia of pyrites; seams in feldspathic gneiss, composed of mixtures of pyrites, sometimes in cubes, with magnetite in rounded nodules similar to those described below, found at the phosphate of lime locality; together with others, not important enough to occupy space in description.

"The HURDTOWN PHOSPHATE OF LIME locality. This celebrated locality is situated a mile or so in a southwesterly direction from the Hurdtown mine, nearer to the bank of the lake. Although not properly an iron mine, it evidently belongs to the same class of formations as the iron mines of this region; there is, besides, a great deal of magnetic iron at this locality, and its description is therefore introduced here.

"At the time of my visit, however, the mine was not in operation, so that the excavations were all filled with water, and could not of course be entered. My examinations, therefore, were necessarily confined to the materials lying upon the surface, from which a large number of very interesting specimens were obtained.

"The principal species of minerals found in this formation are apatite, or phosphate of lime; pyrrhotine, or magnetic pyrites;

common pyrites; magnetite, or magnetic iron; feldspar; and hornblende; occasionally, also, mica, quartz, and calcite.

"(*a.*) The apatite is found in irregular seams in a pure state, either transparent and greenish, or of a fine amber color, generally possessing the crystalline cleavage distinctly, and appearing frequently in distinct and terminated hexagonal prisms of all sizes, up to several inches in diameter. These crystals most usually, however, have rounded edges and angles. It is frequently opaque also, and stained very much with limonite, proceeding from the oxidation of the pyrrhotine with which it is usually intermixed. The most heterogeneous mixtures are found everywhere, consisting of two, three, four, or all of the minerals above mentioned, in masses and crystals of all sizes. The apatite, however, is occasionally found in masses of considerable size almost free from admixture; and consisting of a congeries of crystals of various dimensions, which have very little mutual cohesion, and such masses crumble into fragments beneath the lightest blow of the hammer. The crystals themselves also possess little solidity, cleaving with such ease that it is almost impossible to get one out unbroken. The cleavages are sometimes curved. The best crystals are usually found imbedded in masses of the pyrrhotine.

"(*b.*) The pyrrhotine is very abundant, and is very highly cleavable in structure, showing cleavages several inches across, and sometimes bent and curved. Like the apatite, it is very frangible, and cleaves with great ease. This is probably due, in part at least, to oxidation. It occurs, sometimes, in masses of large size, almost free from other minerals, but usually contains more or less apatite diffused through it, generally in the form of rounded nodules, but sometimes in crystals. A chemical examination will be made of this mineral.

"(*c.*) The common pyrites is less abundant than the pyrrhotine, and occurs mixed with the latter, and in strings, bunches, and seams, associated with every other mineral of the mine. It

was examined for copper and none found, but the analysis indicated the presence in small quantity of some other metal besides iron, and the examination will therefore be repeated as soon as time will permit.

"(*d.*) The magnetite occurs usually in imbedded nodules which are mostly irregularly spheroidal in shape, and have smooth or striated surfaces, the striæ corresponding to a laminated structure or cleavage which pervades the mass, by virtue of which it cleaves into thin plates. The similarity of this cleavage to that of the pyrrhotine, the rounded and irregular form of the nodules, and above all, the fact that it is frequently imbedded in the pyrrhotine, suggest that it is in all probability a pseudomorph after the latter. Magnetite is also found in seams and bunches in the rocks of the mine, in masses of apatite and elsewhere.

"(*e.*) The feldspar of the mine is of a rather curious and unusual character. Thus its cleavage surface O is very brilliant in lustre, much striated parallel to *i* $\bar{i}$, and has also a very curious curved or wavy appearance, the waves being apparently in the direction of one of the cleavages *I*. Such cleavages frequently appear having a diameter of several inches. The feldspar is sometimes of a greenish color and has a smoky translucency. It has occasionally a play of colors on its surface somewhat similar to that of labradorite, but as nearly as could be determined by means of the common goniometer, a difficulty being here occasioned by the wavy surfaces before mentioned, the angle O : *i* $\bar{i}$ = 90 deg., and unlike labradorite it appears to be unattacked by concentrated chlorohydric acid, so that it would seem to be orthoclase. An analysis will be made.

"The other minerals of the locality do not possess any special interest. The hornblende is of a dark green color and sometimes appears in very large crystals, and is frequently mixed with a green transparent or translucent apatite. Small crystals were observed in places, which seemed to be garnets."

Noland Mine, situated two miles and a half southwest of the Hurdtown mine on Noland Point, Hopatcong lake. It has been worked to the depth of forty-five feet, and one hundred and sixty yards on the surface. The deposit is from three to four feet thick, and dips 70 deg. southeast. It is composed of a highly magnetic ore mixed with grains and crystals of hornblende, feldspar, and quartz. The wall-rocks are hornblendic and micaceous schists, coinciding in strike and dip with the ore deposit.

The following is an extract from Mr. Wurtz's Report on the Chemical and Mineralogical Department:

"Roseville Mine.—This mine is at Roseville, Byram Township, Sussex County, between three and four miles in a southeast direction from Andover. It has been worked at intervals for four or five years by the Trenton Iron Company. There are two principal openings, at each of which a very considerable mass of ore has been extracted, and which are both open excavations, no underground workings having yet been undertaken. The ore-bed or rather the two ore-beds, for they are most probably distinct, at these two excavations, which are about two hundred yards apart, are interposed as usual between the beds of the gneiss rock, but the horizontal axes of the two beds are by no means parallel, forming on the contrary an angle with each other of probably 45 deg. This is due to a remarkable curvature in the outcropping edges of the strata, so that while the more southerly excavation has its longer diameter in a direction of about N. N. E., and S. S. W.; the more northerly lies about N. N. W., and S. S. E. At both of the openings the walls of the beds seem vertical at the surface, but at a depth of thirty feet, which is about the depth of both excavations, the dip appears in each case to change to a steep angle towards the E., the beds at the same time becoming narrower. The forms and mode of occurrence of these two ore-beds seem to be quite anomalous, and to present an important departure from the

general rule. At the southern opening the excavation, representing of course the mass of ore which has been mined, deducting that of one or two interstratified seams or 'horses' of rock of small dimensions, is about twenty-five feet in width on an average; over thirty feet in maximum depth, and probably one hundred feet long, and here, both the N. and S. limits of the deposit (at the surface) seem to have been reached. At the N. opening, the excavation seemed a few feet wider, over thirty feet in depth at the N. extremity, and one hundred and fifty feet long. At the N. extremity of this opening at the time of my visit, ore was being broken out, and there appears, from the strong attractions found upon the surface, to be still a considerable body of ore lying in a direction N. of the present workworkings. At a point about one hundred yards to the S. of the S. excavation, another seam of ore appears but two or three feet thick, from which a few tons of ore have been taken.

"The specimens obtained include the ore found in the small seam last mentioned; ore from the S. excavation; specimens illustrating a section across the bed at the N. extremity of the N. excavation, besides a large number of miscellaneous specimens, many of which are of great beauty and interest in a mineralogical point of view, and will be ornaments to the State Cabinet.

"(1.) *Specimens illustrating the section above mentioned.*

"(*a*.) Ore from the E. side of the bed, which is a compact hard magnetic iron, mixed with considerable hornblende and some pyrites. Sometimes also it contains intermixed calcite.

"(*b*.) Ore from the middle of the bed, which is like (*a*), but with less pyrites and hornblende, and no calcite.

"(*c*.) Rock forming a 'horse' in the ore-bed near the N. wall, which is principally composed of white crystalline calcite, usually mixed with hornblende and magnetite in crystalline grains. The calcite has frequently a deeply and curiously striated surface, which gives it a columnar appearance. A soft

green mineral is also frequently present which resembles serpentine, but contains little or no water and is insoluble in acids, and may be talc.

"(*d.*) Ore from the W. side of the 'horse,' which is similar in composition to (*a*), but is granular in structure.

"(2.) *Miscellaneous specimens from N. opening.*

"(*a.*) *Asbestus*, a highly interesting variety, of a light bluish green color, with continuous fibres of very extraordinary length. One specimen obtained presents straight fibres twenty-five inches long, and a large slab, which was presented by Mr. Richard George, superintendent of the Andover mine, is composed entirely of straight fibres twenty inches long, measures fifteen inches across, and about three inches in thickness. These fibres are rather brittle, being flexible only when split up to a considerable degree of tenuity. They are sometimes much bent and distorted. A qualitative analysis showed the presence of silica, of much lime and magnesia, the former apparently in greatest quantity, small quantities of alumina and water, a trace of iron, and a doubtful trace of zinc. It frequently contains white transparent calcite diffused through it, and sometimes a large mass is composed internally of calcite, with but a superficial coating of asbestos. A complete analysis of this interesting mineral will be made.

"(*b.*) *Calcite.* This mineral occurs in various forms, in large crystals and finely granular, opaque and perfectly transparent, colorless and of a dark red color. It contains no magnesia.

"(*c.*) *Epidote;* in beautiful green crystals frequently of considerable size, imbedded in seams in a hornblendic rock which are composed of beautiful crystals of calcite, sometimes perfectly transparent, of large size, and with curved cleavage surfaces, although containing no magnesia. These are among the most beautiful specimens found at any locality during the season.

"(d.) *Garnet*, in small dodecahedrons of a light hair-brown color, with bevelled edges. It is generally associated with the epidote and with calcite having curved cleavages.

"(e.) *Mica*. The variety commonly found here has flexible and non-elastic laminæ, presenting a grey color by transmitted light. This variety forms large masses, in which the lamination is not parallel, but arranged in all directions very confusedly. Another variety is quite abundant which presents small hexagonal plates of a dark chrome-green color by transmitted light, and requires further examination. The latter generally occurs in a rock composed of a mixture of green feldspar and white calcite in crystals of considerable size.

"Other miscellaneous specimens from the N. excavation are a black crystalline hornblende rock, containing seams of pyrites a quarter of an inch wide, and other seams of crystallized calcite and garnet; a bright red colored calcite, arranged in alternate bands with the soft green taloid mineral mentioned under (1 c), the whole forming a seam in translucent quartz, which is also mixed with the green mineral; a rock composed of white and dark red finely granular calcite with the above green mineral arranged in alternate bands; a rock composed of a mixture of white calcite, an olive-green translucent feldspar and magnetite, in small crystals.

"(3.) Ore from the south excavation, which is composed of irregularly crystallized grains of magnetite, mixed with a green soft altered hornblende and considerable pyrites. It has seams filled with asbestus.

"(4.) *Miscellaneous specimens from S. excavation.*

"A rock composed of calcite which presents cleavages several inches in diameter, the surfaces being striated in three directions, these three systems of striæ corresponding to three systems of parallel cleavage planes, perfectly independent of the crystalline cleavages, and easily distinguished from them by presenting dull

surfaces. The crystalline cleavages are usually curved, no magnesia being present. Masses and strings of magnetite are found in this rock, and some specimens contain a brown opaque calcite, associated with light hair-brown garnet.

"Varieties of hornblendic gneiss, one of which is entirely composed of a mixture of crystals of brilliant black hornblende and bright green epidote, presenting a very beautiful appearance; another a mixture of black hornblende and white feldspar, with seams of green epidote, and containing some calcite, as indicated by effervescence with acids; another entirely composed of brilliant black hornblende in small crystals which lie in every possible direction, making beautiful specimens.

"(5.) Ore from the opening S. of S. excavation, which is hard, compact, and contains some pyrites."

"Silver Mine.—This locality is upon the Sussex railroad, between Andover and its terminus at Waterloo, being between two and three miles distant from the former place. The principal opening is two hundred yards or so west of the railroad. It is of small extent, and the place is only of interest from the peculiar character of the seam of ore, which is of considerable size, although from its great irregularity no distinct idea as to its width could be arrived at.

"It is really and truly a *sulphur mine*, magnetic iron being of very rare and subordinate occurrence in it, and the whole mass of the bed being made up of irregularly mingled masses, seams and bunches of pyrrhotine, pyrites, and a dark green cleavable mineral not yet made out with certainty. The quantity of pyrrhotine obtainable at this locality is quite large, if it should ever become of any value for manufacturing copperas or other purposes. The pyrrhotine is generally associated with more or less pyrites. A mica was also found here, in plates two or three inches in diameter, frequently decomposed, and one distinctly hexagonal plate was found evidently belonging to an oblique system making the species muscovite. It has cleavages at right angles to the faces I. I.

"Haggerty Mine.—This mine is one mile and a quarter in a northeasterly direction from Stanhope, near the road leading from that place to Hopatcong Lake. The shaft was nearly full of water so that no examination could be made of the ore *in situ*, but many interesting specimens were picked up on the surface. Among them were large masses of cleavable pyrrhotine, or magnetic pyrites like that found at the Hurdtown apatite locality, and at the Silver mine. This appears to be the predominant mineral at the locality, and occurs in admixture with magnetic iron, also cleavable, and polaric, and contains besides small nodules of phosphate of lime, sometimes transparent and amber colored as at Hurdtown, associated with pyrites in black hornblende.

"Also a dark green feldspar resembling that found at Longcore's mine and at Hurdtown, mixed with quartz, and associated with pyrrhotine.

"Pyrites in seams, irregular strings and bunches, mixed with magnetite, black hornblende and apatite.

"A micaceous gneiss, containing much feldspar, magnetite, etc., the mica having a peculiarly brilliant black lustre, and a mirror-like appearance, and its laminæ, being arranged in an approximately parallel manner, give the rock a very singular and brilliant appearance. The olive-brown color of this mica is so deep that the thinnest films are barely translucent.

"A rock composed of an intimate mixture of this brilliant mica with pyrrhotine, black hornblende, and a green quartz."

Stanhope Mine.—The mine is situated in a ridge about seven-eighths of a mile north of Stanhope, and about four hundred yards E. N. E. of the turnpike from that place to Newton. The first workings that were made there, about sixty-five years ago by Mr. Jonathan Dickerson, are now filled in. The ore taken out at that time was smelted at the Lockwood Forge. It was afterwards worked by Mr. Simeon Dickerson. The iron from this ore was manufactured into scythes, and was considered

very suitable for this purpose. Some five years since Mr. Edwin Post made an opening from twenty-five to thirty feet in depth, about three hundred and fifty yards south-southwest of the old mine, and took out several hundred tons of ore, when it was abandoned on account of the occurrence of a vast amount of pyrites. The ore is composed chiefly of magnetite, iron pyrites and a little hornblende. In some portions of it the pyrites enters sparingly, while in others it constitutes about one-fourth of the whole.

The wall rock is hard and compact, consisting of hornblende, feldspar, grains of magnetic iron ore, pyrites, and a small portion of quartz. The first is the most abundant constituent; and the feldspar and magnetic iron ore, each compose about one-fourth of the whole.

"Lowrance Mine.*—This mine is situated in Roxbury Township, Morris County, one mile and a quarter N. N. W. of Stanhope. Here are one or two small openings on one of two parallel seams which were traceable by their attractions for some distance in a N. E. and S. W. direction. The holes made were so blocked up with rubbish that I could form no accurate idea by actual examination, of the nature of the formation, but from several circumstances, such as the contour of the ground, the appearance of the ore, which though pyritons, did not seem to be valueless, and the distance to which the attractions could be traced, the place was judged worthy of further examination.

"The specimens found here comprise the ore, a heavy compact magnetic iron, containing a small quantity of pyrites; and pieces of black hornblende rock incrusted with transparent opal.

The Mount Olive Mines.

"These comprise a number of openings, situated in the vicinity of Mount Olive, Roxbury Township, Morris County, a few miles in a southerly direction from Stanhope. The principal ones visited were as follows, in the order of their nearness to

* Extracted from Mr. Wurtz's report.

Stanhope: *Osborn's mine*, *Hilts' mine*, *Drake's mine*, and *Stevens' mine*, and there are a number of other openings which have been less explored, to which no distinct names have been given.

"All the seams of ore known in this vicinity were discovered at different recent dates, by Mr. Anthony A. Drake, of Mount Olive, to whom I am indebted for many of the facts given in regard to these mines. The different mines will be described in the order in which they are mentioned above.

"The OSBORN MINE is situated about three miles from Stanhope, on the road to Mount Olive. It was discovered in May, 1848, and opened immediately upon its discovery. The strike of the ore bed is from N. E. to S. W., and its dip probably 45 deg. to the S. E. The workings, which cross the road, extend to a distance of but fifty feet along the ore bed, and to a depth of twenty-five feet, the ore having been reached at the depth of nine feet below the surface, and were suspended on account of the influx of water, and want of machinery, or adequate water power in the vicinity, for pumping it out. The mine is so situated, in the midst of a nearly level expanse of country, that in any operations that may be hereafter attempted, the drainage must be accomplished by steam power. The ore-bed where opened was, at the surface, as stated by Mr. Drake, from ten to fifteen feet in width. Specimens of the ore were obtained, which is magnetic iron, mixed with considerable limonite and decomposed feldspar. It is somewhat polaric.

"HILTS' MINE.—This lies half a mile or more in an easterly direction from the Osborn mine. It was discovered in August, 1854, and was opened immediately. The seam of ore, which appears at the place where opened to be five or six feet wide, and to dip towards the southeast at an angle of perhaps 75 deg., can be traced by its attraction to a considerable distance both to the N. E. and S. W. of the opening. The shaft which was being sunk at the time of my visit, had reached the depth of

twenty-five feet. If the mine should be found worth working, it is contemplated to obtain power for pumping the mine, by erecting a water wheel on a small stream which runs through a shallow valley, a few hundred yards to the south.

"Specimens of the ore were obtained, which is a mixture of magnetic iron considerably decomposed, with a very large bulk of altered feldspar and some limonite. It resembles the ore of Osborn's Mine, though much more impure, and like it is somewhat polaric. Masses of white altered feldspar, sometimes associated with quartz and decomposed hornblende appear in great quantities among the rubbish thrown out of the shaft.

"Drake's Mine—Is situated on the property of A. A. Drake, Esq., of Mount Olive, probably two miles, or more, S. W. of Hilt's mine, and was discovered in Sept., 1854. The seam of ore is on an average about five feet thick, strikes N. E. and S. W., and dips to S. E. about 45 deg. The seam has been opened to a distance of about one hundred feet, and to a depth of about eighteen feet below its outcrop. Not being worked at the time visited. Specimens were obtained of the ore, which is very strongly polaric, quite pulverulent, mixed with much decomposed feldspar and stained with limonite.

"Stevens' Mine—Was discovered in December, 1848, and is situated probably a quarter of a mile or more S. W. of Drake's mine, on a seam of ore striking from N. E. to S. W., which seems to be about in a line with the seam of that mine. The dip is about 45 deg. to S. E., and the workings extend about ninety feet along the seam, whose width at the S. W. end of the workings is two feet, in the middle about four feet, and at the N. E. end about one foot. After going down from fifteen to twenty feet from the surface of the seam, the ore becomes so full of pyrites as to be not worth mining, so that this is the limit of the workings in depth. The specimens collected comprise the hanging wall, foot wall and two varieties of the ore.

„(*a.*) The hanging wall is a finely granular mixture of feldspar and magnetite.

"(*b.*) The mass of the ore is strongly polaric, very frangible and pulverulent, highly decomposed and mixed with much limonite and decomposed feldspar. Some of it is, however, quite heavy and rich.

"(*c.*) A considerable portion of the ore is similar to the above, but so highly polaric as to form the most powerful loadstones that I have ever met with from any locality. A piece of about a pound in weight will lift a tenpenny nail, and if properly mounted would of course do much more.

"(*d.*) The footwall is principally composed of altered feldspar, but contains also much magnetite, and is much stained with limonite. The feldspar contained in it is apparently much more decomposed than that in the hanging wall.

"On proceeding northeast from Stevens' mine towards Drake's mine, a number of other openings are encountered, upon a seam of ore which is apparently a continuation of that at Stevens' mine, and which crosses the property of John Drake, of Mrs. Solomon, and of Charles Solomon. On the property of John Drake, where this seam of ore was first discovered in December, 1848, and where it was first opened immediately upon its discovery, immediately adjoining Stevens' mine, is an opening from which specimens of two varieties of ore were obtained, namely, from near the surface and from a few feet below, containing pyrites.

"(*a.*) Surface ore; similar to that of Stevens' mine, but containing, it may be, less feldspar.

"(*b.*) Ore from below; very heavy and dense, the pyrites being diffused through it very uniformly in small strings and bunches. It is not at all, or at most very feebly, polaric.

"The next opening, but a few yards farther northeast, is on the property of Mrs. Solomon, and the ore here is very similar to the above, but less polaric.

"Some hundreds of yards farther northeast, on property of

Charles Solomon, are several openings, and at one place two side by side, which are evidently upon two distinct parallel seams of ore. Specimens were obtained of the ore from each opening.

"(*a.*) Ore from the northwest seam; similar to that of Stevens mine and the other openings southwest of it, and may therefore be on a prolongation of the same seam, but contains less decomposed feldspar, is less polaric, and denser.

"(*b.*) Ore from the southeast seam; denser still, and more compact than (*a*), but still containing decomposed feldspar; possesses little or no polarity.

"On attentive examination of the ores of this Mount Olive district, there appears to be a great similarity in character among them. Thus they all retain indications of having been subjected to intense chemical action, being impregnated with limonite and associated with highly altered feldspar. On examination of the small opening called Stevens' mine, the only one now in operation in which the excavation has been carried to sufficient depth to expose the structure of the formation, throws considerable light upon the cause of these appearances. We there see distinctly that the whole seam has formerly been loaded with pyrites, which for a few feet below the surface, or as far as the action of atmospheric oxygen in solution in infiltrating waters could extend, has been removed by oxidation, and a quantity of limonite only left to indicate its former existence. Now, considering the large quantity of limonite found associated with all the other ores of this section, analogy leads us irresistibly to the supposition that in all probability the structure of the other seams is the same, and that after descending below a point which is probably at or about the water-level of the locality, they will be found to be pyritous to a greater or less degree.

"Marsh's Mine.—This mine is situated upon Schooley's Mountain, Washington Township, Morris County, probably a quarter of a mile from the Heath House, a few rods to the right hand of the road leading to Hackettstown. There are two open-

ings here within a few yards of each other, from one of which ore was being taken out at the time of my visit. The deposit of ore here does not by any means present the symmetry in strike and dip which is usually found, and from the excavations I could not make out accurately the form of the deposit. Specimens were obtained of the ore and some of the associated rocks.

"The ore is a hard, compact, very tough mixture of a nearly amorphous magnetite with crystals of black hornblende, and is much stained by limonite.

"The miscellaneous specimens comprise hornblende rocks, sometimes composed of large crystals, highly pyritiferous, and covered with efflorescences of soluble ferruginous salts; a feldspathic rock, composed of large crystals, much altered and stained with limonite; an altered feldspar which presents wonderfully accurate imitations of chips of rotten wood.

"About a quarter of a mile in an easterly direction from Marsh's mine lies another opening, of small extent, called 'Dickinson's mine,' upon an ore-bed of similar character. Specimens of the ore appear to be similar to those of Marsh's mine, but contain more hornblende and are still more amorphous.

Mines of the Ringwood, Copperas, Splitrock, Hibernia, Mount Hope, Mount Pleasant, and Mount Ferrum mountain range.

The Ringwood Mines.—These mines are situated in a series of hills varying in height from one hundred and fifty to three hundred feet, and lying about one mile west and west-southwest of the village of Ringwood, Passaic County. They comprise eight distinct mines, besides several smaller openings, which were, for the most part, worked previous to the Revolutionary war, by the 'London Company,' who smelted the ore at several forges and furnaces in Passaic and Morris counties. Subsequently they passed into the possession of the Ryerson family, and in October, 1853, were purchased by the present owners, "The Trenton Iron Company," who have worked some of them very extensively since that time.

One of these mines, known as the OAK MINE, is situated on the southeastern slope of "Hope Hill," about one mile and a half northeast of the "Hard," "Blue," and "Mule" mines. It was opened by the London Company in 1762 or '63, and was, when they discontinued operations, about thirty feet deep. Afterwards Mr. Jacob N. Ryerson worked it thirty feet deeper; since which time it has been abandoned, and is now filled with water to the mouth of the level driven into it. The ore occurs in the form of an irregular deposit, occupying a vertical position, with a strike about N. E. by S. W., and a pitch in the former direction at an angle of 55 deg. It is of a black color, having a bright metallic lustre; of a compact granular structure, and for the most part quite pure, containing a small quantity of quartz and feldspar in grains, the latter in a decomposed state.

There are several openings at the south and southwest of the Oak mine, which were made by the London Company; but a comparatively small quantity of ore has, however, been taken from them. This ore is generally quite pure, and like that of the Oak mine, pitches beneath a capping of rock to the northeast. It varies in thickness at these openings from five to ten feet.

The PETERS MINE, another of the group, is situated one mile northeast of the Blue Mine, and was opened previous to the Revolution by the London Company, who worked it very extensively. They sunk several shafts, and drove in an adit-level from the base of the hill. It is estimated that they took out not less than fifty thousand tons of ore. Eighteen years ago Mr. Jacob N. Ryerson cleared out the old shafts and adit, and took out about one thousand tons of ore. The London Company, in working the mine, took out only that which contained the fewest impurities.

Another of these mines, known as the CALER MINE, is situated at the southeastern base of a low hill, half a mile northeast of the Blue Mine. It was opened by Robert Erskine,

the agent of the London Company, by whom only a small portion of ore was taken out. About four thousand tons have since been removed from it, and smelted at the furnace of Horace Gray, Esq., at Pompton. The deposit is from sixteen to twenty feet in thickness; the opening is from twelve to fourteen feet in depth, and about seventy in length. At the southeastern side of the opening is a narrow 'horse,' next to which there is ore, a few feet in thickness, very soft and much inclined to crumble. This is likewise the case with all the ore near the surface; but on descending it becomes firmer in structure, and contains fewer impurities. On the southwestern part of the opening feldspar is quite abundant; in other parts it occurs mingled with quartz; and near, and at the surface contains rounded particles of phosphate of lime. About seventy-five yards to the N. N. E., in low ground is another opening, where the same kind of ore occurs.

The New or Wood Mine, about four hundred yards northeast of the Blue Mine, was opened during the winter of 1854, by the Trenton Iron Company, who have taken about three hundred tons of ore therefrom. The deposit is twelve and a half feet in thickness, including five feet of rock intervening between its two parts, the northwestern of which is two and a half feet thick, and the southeastern five feet thick. The ore pitches down towards the northeast at an angle of 30 deg., and dips at 88 deg. to the southeast. It is of a compact, granular structure, of a black color, possesses considerable lustre, and contains a very little hornblende, together with seams of translucent quartz. The wall rock upon the southeast side, is a coarsely granular mixture of feldspar, quartz, hornblende, magnetic iron ore, and epidote. That upon the opposite side is syenite, consisting of flesh-colored crystalline feldspar, hornblende, and more or less quartz and epidote.

The Blue Mine is situated about one mile west-southwest of Ringwood. It was opened by Mr. John Ryerson, who worked

it to the depth of sixty feet, and from one hundred and ten to one hundred and fifteen in length. In 1853 the Trenton Iron Company, under the direction of Mr. Philip R. George, commenced working it, and by November, 1855, sunk a shaft to the depth of one hundred and thirty feet, at which depth it has been worked, sixty feet northeast, and fifteen feet southwest of the shaft. A tunnel was also driven one hundred and seventy-five feet in length, from the southeastern slope of the hill, striking the deposit about thirty feet below the surface. Since October, 1853, about six thousand tons of ore have been taken from this mine. It occurs in the form of an irregular deposit, with a strike about N. E. by S. W., and a vertical dip. Its thickness varies from ten to twenty feet, and is greatest about one hundred and twenty feet from the surface.

The ore is massive, of a light blue color, possesses a bright metallic lustre, and contains a small quantity of light green hornblende, with very small grains of light grey quartz. Iron pyrites also enters into it sparingly. It is traversed by joints running at right angles to the strike.

The Mule Mine.—This mine is situated about thirty yards south of the shaft of the Blue Mine. It was opened and worked about sixty feet in length, and forty feet in depth, by Mr. Jacob N. Ryerson, but for the last twelve or fourteen years nothing has been done in it.

The ore occurs in the form of an irregular deposit, from fourteen to twenty feet in thickness, in a vertical position, and pitching beneath a capping of rock to the N. N. E., at an angle of from 40 to 50 degrees. A few feet beneath the surface, at the N. N. E. part of the workings, it divides into two branches, the one continuing in that direction, and the other turning to the north, towards which point it has been worked about twenty-five feet, and to the depth of thirty feet.

The north northeastern branch continues, probably, across the tunnel leading into the Blue Mine.

The ore is of a blue color, highly magnetic, and possessing a metallic lustre. In texture it is compact, occasionally inclined to crystalline. It is nearly free from impurities, containing a little hornblende, and near the rock capping it, a small proportion of phosphate of lime (apatite.) This latter mineral is of a yellowish white color, and of a slightly resinous lustre, and occurs in rounded particles, generally very small.

The rock capping the ore is an aggregate of grains of white feldspar partially decomposed, black crystalline hornblende, and small scales of black and brown mica. A small portion of it contains grains of magnetic iron ore, with a little epidote.

The Hard Mine.—This mine is situated thirty yards southwest of the Blue Mine, and has been worked to a depth of one hundred and seventy-five feet. Fifty feet of this distance have been sunk by the Trenton Iron Company; and at that depth they have worked it fifty feet southwest, and one hundred feet northeast of the shaft, and have taken out about fifteen hundred tons of ore, most of which has been used at Pompton. When visited, the mine was temporarily abandoned, and partly filled with water, so that a detailed and satisfactory examination could not be made at its lower portion. The general character, both of the ore and rock, with their relative position, was determined from the part exposed.

The ore occurs in an exceedingly irregular deposit, the general strike of which is about N. E. by S. W. At the shaft it is divided by an intervening rock ("horse"). Like that at all the other mines in this section, it pitches to the N. E. beneath the rock. At the southeast termination of the mine, at the junction of the ore and rock, it has been worked down at an inclination of 60 deg. It is of different degrees of purity. That from the branches of the deposit, next to the "horse," is of a bluish black color, with a bright metallic lustre, is massive and compact in structure, and contains more or less phosphate of lime, feldspar, epidote, and pale green hornblende. That from the bottom of the

shaft contains a much less proportion of these minerals. It is highly magnetic, and in some parts contains traces of titanium.

The rock of the "horse" is composed of yellowish white compact feldspar, light colored quartz, hornblende and yellowish green epidote, all occasionally intimately mixed with scales of greyish white mica, and numerous grains of magnetic iron ore. The first three are most abundant, and in about equal proportions.

The wall-rocks vary considerable in character, though they resemble, for the most part, the rock of the "horse." In some parts the mica is quite abundant, while in others it is comparatively scarce, and unevenly scattered through the rock.

The Cannon Mine.—This mine is situated about eighty yards northwest of the Hard Mine. The intervening rock is gneiss and hornblendic slate; the former a somewhat coarse admixture of hornblende, feldspar and mica; the latter consisting of yellowish white feldspar, light grey quartz, light green hornblende, and more or less magnetic ore in grains.

Within an area of one hundred and twenty-five feet, by about one hundred, there occur not less than four deposits of ore, though doubtless some that appear to be such, are but branches of a single deposit.

The first deposit occurs at the southwestern part of the open works. It is twenty-five feet in length at its outcrop, and ten in thickness. Tne Trenton Iron Company have opened here, and taken out about two hundred tons of ore.

The second deposit is in the southeastern side of the works, and is fifty feet in length, by thirty-four in thickness. A long time since an opening was made into it to a depth of from twenty-five to thirty feet, but is now filled with water and rubbish.

The third and fourth deposits occupy the northwestern part of the open works. The extreme northwestern of these is thirteen feet thick, and sixty feet long; the other is twenty feet thick, and fifty feet long. They were opened and worked to a

depth of from twenty-five to thirty feet by the London Company.

The ore of this mine is of both light and dark blue colors, highly magnetic, of a metallic lustre, and varying in structure from finely granular to coarsely crystalline. This change in structure is observed to occur within very small limits; sometimes the granular changing to crystalline within a few inches. It is not entirely free from impurities, small proportions of quartz, feldspar, epidote, etc., entering into it. It also contains, sparingly, iron pyrites. The ore occurs also in grains arranged in laminæ through the rock, increasing in its proportion, at various places, until it constitutes the whole mass.

About twenty miles southwest of the Ringwood mines, is the Mount Hope Tract—one of the earliest opened and most extensive series of deposits in this metalliferous belt. And between the Ringwood and Mount Hope tracts, are other extensive deposits of ore, as those at Split Rock, which will be considered in a future report.

The Mount Hope Mines.

The Mount Hope mines are situated in and near Mount Hope, three miles northwest of Rockaway. There are, in all, nine deposits: four in Mount Hope, three in Hickory Hill, and two in Mount Teabo, all of which belong to the Mount Hope Company. The oldest workings are in what is called the "Open Work," "Jugular," or "Mount Hope Vein," formerly known as the Mount Hope Blue Mine. These old workings, consisting of two inclined planes, carried down at an angle of 25 degrees, to the depth of one hundred feet, are about to be cleared out and entered, by means of an adit, now being driven into them from the foot of the hill. The deposit, which at its greatest thickness is twenty feet, will average throughout about ten feet, and has a dip generally of 68 deg.

The following are extracts from Mr. Wurtz's report:

"The entrance to the mine is upon the southwest slope of the hill, and the ore has been taken out from the surface downward,

following the outcrop of the ore-bed for some hundreds of yards up the slope of the hill, to a considerable depth, and making an excavation open to the sky during that part of its course nearest the entrance, whence the name 'open workings,' or 'open cut,' by which it is known in the vicinity. The entrance to this mine, besides being very imposing in appearance, presents several phenomena which are highly instructive with reference to the structure of these formations. The strike of the outcrop is, as usual, about N. E. and S. W., and the sides of the excavation, which are of course the walls of the ore-bed, representing therefore its dip at this point are nearly, if not quite, vertical, although elsewhere the dip is steep towards the S. E., as usually the case. At the N. E. extremity of this 'open cut,' or entrance to the mine, where a portion of the ore has been left standing above the entrance to the workings beyond, this entrance being only high enough to admit the cars which run upon the tramway, it is distinctly seen that the ore-bed is stratified, the strata being parallel to those of the surrounding gneiss rock. Another phenomenon to be seen in this excavation is worthy of an allusion. The perpendicular foot wall is covered with parallel markings, or rather furrows, resembling striation on a large scale; these furrows each extending continuously along the whole visible course of the foot wall, and having a gentle inclination towards the N. E.

"The specimens collected from this mine illustrate two sections across the formation, one at the extreme northeast stopes, and the other at the extreme southwest point where the ore is accessible, or in a small excavation lying still farther to the southwest than the great 'open cut' before spoken of. Following the usual plan, the latter will be first described.

(1.) Extreme southwest stopes. The hanging wall is highly hornblendic and schistose, with interposing layers of brown mica. The hornblende is in large crystals and is somewhat altered.

"The ore is crumbly granular ('shot ore'), containing a large quantity of granules of apatite, and of limonite proceeding probably from oxidation of pyrites.

"The foot-wall is similar to the hanging wall, but contains considerable decomposed feldspar and some magnetic iron. It is apparently more decomposed than the hanging wall.

"(2.) Extreme northeast stopes. The hanging wall was not exposed, and its character could not be well ascertained, nor specimens of it obtained.

"Ore from the southeast side of a layer of rock or 'horse,' which here divides the ore-bed, is a heavy, hard crystalline mass, containing a few granules of apatite.

"The horse is a compact hard mass of small crystals of feldspar, with a little hornblende.

"The ore on the northwest side of the 'horse' is granular and crumbly, and contains much green hornblende and a very large quantity of apatite, much more than that on the other side of the horse. In some specimens fully half the mass appears to be this mineral. The differences in composition and structure of the two divisions of the ore-bed on opposite sides of the horse are here especially remarkable.

"The footwall is schistose, and composed of crystals of brown mica, black hornblende, and white feldspar, the latter predominating in quantity."

Another deposit in Mount Hope, on the southeast side, is called the "Teabo Vein," which has been but little worked. On the northeast side, towards Hickory Hill, two or three small shafts and levels have been driven into it; and on the top of the hill, a shaft has been sunk on the tunnel, or adit, which is being driven from the southeast side of the hill, at right angles to the deposits, in order to cut all four of them. This tunnel has already been carried past the Teabo Vein, the thickness of which, in it, is four feet.

Next to this deposit, upon the same side of the hill, is the

"Brannin Vein," upon which four or five shafts have been sunk to an average depth of thirty-five feet. This deposit is very variable in thickness, measuring in some places seventeen feet, and in others "cutting out" to one or two.

The most southeasterly deposit is called the "South Vein," and has been worked only a short distance from the tunnel. Its thickness, so far as it has been explored, is four feet.

The ore, wall rocks and miscellaneous minerals of the three last mentioned deposits have been examined by Mr. Wurtz at their intersection by the tunnel, known as the "Mount Hope Tunnel," and are described as follows:

The Mount Hope Tunnel.—"This is the most important mining work in this vicinity. It was commenced with the intention of cutting transversely, at the lowest possible point, the 'jugular vein,' and any other seams of ore which may exist in Mount Hope, and in the course of its progress it has cut at right angles, within a distance of about five hundred feet, three ore seams, without yet having reached the main seam. Its entrance is at the foot of the hill on the S. E. side, and it forms the terminus of a railroad now building by the Company to connect with the Morris Canal at Rockaway, four miles distant. The tunnel is of sufficient dimensions to admit this railroad and ore-cars of a large size running upon it. At the time of my visit, the tunnel had been driven in as far as a seam of ore about five or six feet in width, situated five hundred and four feet from its entrance. This seam, from a supposed identity with that of the Teabo Mine, is called the 'Teabo Vein,' and another smaller seam about three or four feet wide, forming the second one cut by the tunnel, is called for a similar reason, the 'Brannin Vein.' In order not to attach too much importance to these suppositions of identity, which may not be verified by future investigation, I shall designate the three seams according to the order in which they are intersected by the tunnel; the 'Teabo Vein,' being called the third seam; the 'Brannin Vein,' the second seam,

and another small seam, but two or three feet wide, still nearer to the entrance of the tunnel, the first seam.

"Specimens were collected from this tunnel, comprising not only the ores, hanging and foot walls of the three seams, but also the rock at the entrance of the tunnel, and at two other points, three hundred and thirty and four hundred and thirty feet, respectively, from the entrance. The number of miscellaneous specimens also collected from the tunnel is large, and their character generally very interesting.

"(1.) The rock at the entrance of the tunnel is a coarse-grained schistose mixture of quartz and feldspar, the latter being very much decomposed.

"(2.) The first seam of the hanging wall is a very much decomposed feldspathic gneiss, mixed with much limonite. The cleavages of the feldspar are quite large.

"The ore is granular crumbly, and mixed with very much altered apatite.

"The foot-wall is a highly decomposed coarse mixture of large crystals of feldspar and quartz, mixed with much limonite. It is more decomposed than the hanging wall.

"(3.) Of the second seam the hanging wall is highly schistose in structure, and composed of black mica and white feldspar.

"The ore has a laminated structure, and contains considerable apatite. It contains fissures whose surfaces are polished and resemble 'slickensides.'

"The foot wall is a coarsely granular schist, composed of feldspar and quartz, containing particles of magnetic iron.

"(4.) The rock at three hundred and thirty feet from the entrance of the tunnel is a large granular, somewhat decomposed, schistose mixture of feldspar and quartz, with particles of magnetic iron interspersed.

(5.) "The rock at four hundred and thirty feet from the entrance is a schistose mixture of green feldspar, white quartz and particles of magnetic iron, containing seams of pyrites.

"(6.) Of the third seam the hanging wall is similar in appearance to the rock last described, but of finer texture and containing pyrites in numerous diffused particles.

"The ore is very hard, compact, and fine-grained, mixed with a good deal of quartz, and has a well developed jointed cleavage. It frequently contains much pyrites.

"The foot wall is similar to the hanging wall, but contains also seams of red hematite, with pyrites.

"(7.) Among the miscellaneous specimens are the following:

"A variety of specimens of pyrites, generally in seams in masses of magnetic iron, these seams being sometimes as much as two or three inches in diameter. It is sometimes associated with crystals of calcite. The abundance of pyrites in some of the rubbish heaps from the tunnel leads to the supposition that there may be seams of the rock intersected by the tunnel sufficiently rich in this mineral to be made available at some future day, whenever pyrites shall have acquired a marketable value in this country for the purpose of manufacturing sulphur and sulphuric acid.

"A schist composed of white feldspar and black hornblende, the latter predominating, containing large crystals of hornblende, and irregular masses in great number, sometimes assuming the form of rounded nodules, and presenting precisely the appearance of imbedded pebbles, of a soft green mineral, having a laminated structure resembling crystalline cleavage, but with dull surfaces. This mineral has about the hardness of apatite, for which it was at one time mistaken, but on chemical examination was found to contain but a small quantity of phosphate of lime in admixture. It will be submitted to further examination. The patches and nodules of this green mineral imbedded in the black hornblende give this rock a very singular appearance, which is enhanced by seams of green epidote, of very common occurrence in the mass, these seams consisting sometimes also of a mixture of green epidote and a brown mica.

"Masses consisting of very irregular mixtures of large crystals of apatite, sometimes several inches long and of a light brown color, with quartz, green epidote, black mica, altered hornblende, and a white calcite which has a pearly lustre and curved cleavage surfaces, but contains no magnesia. These masses occur associated with a hard, compact, schistose rock, consisting of small intermixed crystals of black hornblende and white feldspar, containing seams of epidote half an inch or more in diameter and of a beautiful grass-green color. In this rock are also found, associated with crystals of apatite, dark brown mica and calcite, a peculiar variety of pyrites in crystals, which contains copper, but is much harder than chalcopyrite. It tarnishes on fractured surfaces to bronze and irised tints. It may be a new species, and will be thoroughly examined. But the most singular mineral here found, which can scarcely be other than a new species, occurs generally intimately associated with the above mentioned pyritoid mineral. It has one perfect cleavage giving surfaces of a bright metallic lustre and lead grey color. Its streak is uncolored. Its hardness as great as that of quartz or greater, and its weight apparently not much less than that of magnetite. The imperfect chemical examinations which have so far been made, have established the existence in it only of titanic acid, alumina (?) and zinc. Fortunately one *crystal*, incomplete, though of considerable size (an inch and a half in diameter), was found, which will admit of the approximate measurement of some of the angles, and thus probably of the determination of the crystalline form. Whenever time shall permit, a complete investigation of this substance will be made.

The remainder of the miscellaneous specimens are generally of less interest; comprising seams of chalcedony associated with pyrites in magnetic iron; nodules of red hematite in an irregular mixture of quartz and greenish feldspar; a schist, some of the laminæ of which are mixtures of magnetic iron and pyrites, others magnetic iron and green feldspar, etc.

"From a shaft sunk on the second seam of the tunnel, situated about forty yards northeast from the latter, and forty feet deep, specimens of the ore were obtained, which is a granular and crumbly ('shot ore') mixture of magnetic iron with a very large quantity of apatite in granules about the size of grains of wheat.

"On the northeast slope of Mount Hope there are a number of other mines, known by the names of the Clay Mine, Welch's Drift, Gallagher's Cut, etc., which were not in operation at the time of my visit, and time did not permit their examination. At the Clay Mine were picked up among the rubbish masses of quartz, which in places were honeycombed and full of cavities containing limonite, and frequently lined with beautiful drusy crystallizations of quartz and mammillary chalcedony. At Welch's Drift were picked up specimens of black hornblende schist, containing in fissures a transparent violet-colored mineral which is probably fluor spar, but is in too small quantity to be examined. Crystals of apatite of some size were also observed here. At Gallagher's Cut, the same violet-colored mineral was found in small quantity in fissures, and specimens of black crystalline hornblende were obtained, containing disseminated apatite, the latter sometimes in crystals several inches in their dimensions."

The Hickory Hill deposits are more to the northeast than those in Mount Hope. The workings in them are not of great extent, being chiefly levels driven for a short distance into the hill. Their average thickness, so far as opened, is three feet, with a dip of 65 deg.

* "In the elevation lying contiguous to Mount Hope on the northeast are two mines known by the names of Hickory Hill North Drift and Hickory Hill South Drift. Of these, time permitted only the examination of the North Drift. Specimens of the ore and of the two walls were obtained.

"The hanging wall is a coarsely crystalline highly hornblendic schist, containing some diffused feldspar and brown mica.

* From Mr. Wurtz's Report.

"The ore is a finely granular mixture of magnetic iron and quartz.

"The foot-wall is a very irregularly laminated schist, composed of a mixture of variously sized crystals of greenish black hornblende, white feldspar, quartz and brown mica. It is somewhat decomposed.

"About half a mile in a southeast direction from Mount Hope lies a deposit of bog iron ore or limonite, said to be of considerable extent, covering fourteen or fifteen acres of ground and having a thickness of from one to two feet. It lies but a few inches below the surface, and is mixed with pebbles and other extraneous materials in places. The railroad to Rockaway, now in process of construction, passes through the midst of it. Specimens of this mineral were collected, and a partial analysis has been made, which indicates the presence of much manganese, much less phosphate of lime than those deposits generally contain, no sulphur, no lime, and no magnesia. This result shows that this ore must be of value for mixing with some other ores, and a complete analysis will hereafter be made.

"In this connection must also be mentioned another deposit of bog ore found about one mile north of Dover, along the road to Mount Hope, on the property of Mr. James King. The appearances presented here are such as should encourage further explorations. Specimens were obtained, but no opportunity to examine them has yet been had, except to ascertain that it also contains considerable manganese.

"In the immediate vicinity of Dover, as on the meadows lying east and northeast of the village, indications of bog iron ore were observed, and future observations will undoubtedly develop many deposits of this substance throughout this whole section. The great abundance of chalybeate or iron springs observed throughout the whole of the gneiss region, of the deposits from which these beds of bog iron ore consist, shows that there must be a great quantity of it in various places. Too little attention, in

my opinion, has been paid to this ore throughout this part of the country. The manganese which it usually contains must make it of value in many cases for mixing with the magnetic ores."

On the southeast side of Mount Teabo there are two deposits, upon the property of the Mount Hope Company, both of which have been extensively worked. One of them has, however, been temporarily abandoned. Upon the other, which is called the "Elizabeth Vein," the workings consist of a level which has been driven for a distance of two hundred and forty-one feet, passing a fault of five feet. At this distance the deposit begins to rise towards the surface, "cutting out" in the bottom. Higher up the hill three shafts have been sunk, the deepest of which is ninety feet. The average thickness of the ore is six feet, and its dip 72 deg. This deposit is very curiously curved in a series of undulations, in the direction of its dip; and the dip changes every seven or ten feet. The workings upon the the abandoned deposit are said to be very extensive, consisting of three shafts about two hundred feet in depth. This deposit, like some of the others, varies considerably in thickness, being from three to eleven feet.

Teabo Mine.—Towards the southwest, and on the southwest side of Mount Teabo, is the Teabo Mine, now owned by the Glendon Company. But one deposit has been opened at this this place, though it has been worked to a great extent, the main shaft being more than two hundred feet in depth.

* "At the time of my visit it was not in operation, and although mostly free from water, not very accessible on account of the decayed and broken condition of the ladders by which the descent is made into the mine. With much difficulty, however, and at considerable risk of life and limb, specimens were obtained from the bottom of the principal shaft, about two hundred feet below the surface, comprising the hanging and foot walls, and the ore lying next to each. A number of miscellaneous specimens of

* From Mr. Wurtz's Report.

interest were also found among the rubbish around the mouth of the shaft. On account of the difficulty, or rather impossibility of access, no examination was made of the form and dimensions of the ore-bed.

"The hanging wall, at two hundred feet deep, is a micaceous schist, sometimes containing much magnetic iron in seams and bunches, and some white feldspar.

"The ore next the hanging wall is very heavy and hard, contains a few granules of apatite, and considerable quartz.

"The ore next the foot-wall is very similar in appearance, but contains considerable mica.

"The foot-wall is like the hanging wall, but more schistose in structure.

"The miscellaneous specimens are principally micaceous and black hornblendic schists, in some the hornblendic cleavages being quite large. In one was found a perfect crystal of hornblende, in the form of a hexagonal prism, derived of course from an oblique rhombic."

Allen Mine.—About half a mile southwest of the Teabo Mine are the deposits in which the Allen and Richard Mines are situated. At the Allen Mine there is but one deposit, which is, however, divided for some distance below the surface by a "horse." At the junction of the two parts the mass is twenty-two feet in thickness. A pitch towards the northeast is quite perceptible, the ore "cutting out" at the southwest end, as in the Elizabeth Drift at Mount Hope. The working of the mine is, at present, confined to the northeast end. It is entered by an adit six hundred and thirty feet in length, penetrating the hill at right angles to the course of the deposit, which at the entrance of the adit is twenty-three feet in thickness. The work has been carried on from the adit towards the northeast, for a distance of two hundred and thirty feet; and towards the southwest about three hundred and fifty feet. The thickness of the ore at the northeast end, near the bottom of the workings, is nine feet; at the southwest end, near the top, it is four feet. The dip is about 65 deg.

From this mine to the canal the distance is about two miles and a half.

* "Extensive and highly interesting suites of specimens were collected at this mine, illustrating sections across the formation at three different places; namely, at the northwest stopes, in the deepest part of the mine, just where the rock or 'horse' comes in and divides the ore-bed; at the extreme southwest portion of the mine; and at a point about intermediate between the two ends. Specimens were obtained also from the small southeast seam in the northeast workings, near the point where it thins out, illustrating a section across it, besides a very large number of curious and interesting miscellaneous specimens.

"(1.) Northeast workings, or deepest part of the mine.

"(*a.*) The hanging wall here is a very singular rock, being of a schistose structure, and apparently composed of an intimate mixture of magnetic iron with another mineral, probably hornblende, both the constituents being in very small particles. Its peculiarity consists, however, in containing numerous rounded nodules, which are composed of a greenish feldspar with mica and magnetic iron, all in small crystals; around which the laminæ of the rock are curved concentrically, thus showing them to be true pebbles, or the debris of a pre-existing rock. Some of these pebbles are themselves schistose in structure, their lamination not being conformable with that of the surrounding rock, thus indicating still another previous epoch of deposition. This rock contains frequently also large seams of brilliant pyrites, and numerous fissures and cavities which are lined sometimes with quartz crystals very perfectly formed, mixed with limonite, sometimes with incrustations of a very delicate transparent mammillary opal, sometimes with very handsome rhombohedral crystals of a pure white opaque *chalybite*.

"(*b.*) The ore on the southeast side of the bed, next to the hanging wall, is very dense, heavy, hard, pure and fine-grained,

* From Mr. Wurtz's Report.

with the jointed structure strongly developed. The two principal joints being about at right angles to each other, divide the mass into rough rectangular prisms.

"(*c.*) The 'horse,' or wedge of rock which divides the ore-bed at this point, is a compact, tough, coarsely granular mixture of feldspar and magnetic iron.

"(*d.*) The ore on the northwest side of the bed, next to the foot-wall, is crystalline, usually granular and pulverulent ('shot ore'), and mixed with some quartz.

"(*e.*) The foot-wall is a mixture of small crystals of a greenish feldspar with black hornblende and considerable magnetic iron, containing also seams of the latter mineral.

"(2.) Small seam on the southeast side of the horse in northeast workings. (*a.*) The hanging wall of this is a compact, tough, granular, crystalline feldspathic rock, containing patches of hair-brown mica.

"(*b.*) The ore is coarsely granular and somewhat crumbly, with a subschistose structure. It contains some apatite, and is feebly polaric.

"(*c.*) The foot-wall is a schistose feldspathic gneiss with considerable intermixed mica and magnetic iron.

"(3.) Section at the intermediate part of the mine. The hanging wall of the southeasterly of the two seams is a schistose mixture of small crystals of feldspar, with a little dark brown mica.

"The ore of the southeast seam is a pulverulent granular magnetic iron, mixed with quartz and granules of apatite. It is a little polaric.

"The foot wall of the N. W. seam much resembles the foot wall at the N. W. workings, but contains more mica, and less magnetic iron. Cavities were observed in it containing the same white chalybite crystals, described as occurring in the hanging wall at the N. E. workings, sometimes soft and altered, but retaining their form and whiteness. Crystals of quartz were also found in the forms of double hexahedral pyramids, and terminated hexagonal prisms, tolerably perfect and transparent.

"(4.) Extreme S. W. workings. (*a.*) The hanging wall of the S. E. seam at this place is finely granular and schistose, being almost wholly decomposed feldspar, with a few grains of limonite and decomposed hornblende.

"(*b.*) The ore of the S. E. seam could not be obtained.

"(c.) The rock separating the two seams is here a micaceous schist in a high state of decomposition, and contains some decomposed feldspar. It somewhat resembles in appearance and structure the hanging wall at the S. E. end.

"(*d.*) The ore of the N. W. seam is heavy, compact, and jointed, and is mixed with a little apatite, quartz, and decomposed hornblende. It is considerably stained by limonite.

"(5.) The miscellaneous specimens are as follows:

"(*a.*) Masses of feldspar of a greenish or greyish color, having continuous cleavages, frequently six or more inches across. Masses were found several feet in diameter, composed of almost pure feldspar, presenting throughout cleavage surfaces of these dimensions. These crystalline masses are sometimes pervaded entirely by seams of black hornblende, without in the least degree interrupting the continuity of the cleavages. The angle between the two principal cleavages, measured with the common goniometer with the greatest precision possible, seemed to be a right angle, and the mineral is therefore orthoclase.

"(*b.*) The most interesting cabinet specimens collected at this mine are masses having a regular pudding-stone structure and appearance, which are composed of sharply angular masses and nodules of crystalline granular magnetic iron, evidently the fragments of a formerly existing formation, which has been broken into pieces by violence, cemented together by a white opaque crystalline carbonate of iron or chalybite. The color of this chalybite is so purely white, and it is so generally free from all stain or tarnish, and has such a brilliant pearly lustre, that it was mistaken for pearl spar, or dolomite, until examined chemically. Cavities are found lined with beautiful rhombohedrons

of this mineral, having curved surfaces as is common with chalybite. Besides carbonate of iron, it contains small quantities of the carbonates of lime and magnesia, but is unacted upon by acids, unless boiling. It occurs sometimes associated with large masses of pulverulent limonite, probably the product of its own decomposition; sometimes also with crystals of pyrites, of the metamorphosis of which it may itself be a product. It sometimes has hexagonal plates of an olive-green mica (phlogopite?) associated with it, which have not yet been examined.

"(*c.*) A hard compact crystalline black hornblende schist, containing a little feldspar and interspersed grains of pyrites, pervaded by seams of magnetic iron and bright green epidote.

"(*d.*) Highly interesting specimens were obtained of regular fissure veins on a small scale, which pervade the magnetic iron. A transverse fracture of one of them is exceedingly beautiful, besides being very instructive with regard to the mode of formation and structure of fissure veins. Both walls are lined with a coating very uniform in thickness, of brilliant pyrites, while the centre is filled with crystalline white chalybite. In some places where the vein thickens up, crystalline bunches of quartz appear imbedded in the chalybite.

"(*e.*) A black hornblende schist, with some diffused crystals of white feldspar, containing the peculiar angular masses of magnetic iron, with large crystals of orthoclase, and nodules of green epidote.

"(*f.*) Some of the quartz contains minute particles of chalcopyrite, (copper pyrites.)

"(*g.*) A massive schist, composed of black hornblende, greenish feldspar, and magnetic iron, all these minerals being in large crystals, and the schistose structure of the mass well developed.

"(*h.*) Rhombohedrons of chalybite, with the faces covered with drusy crystallizations of quartz.

"(*i.*) Seams of magnetic iron in hornblende schist, not more

than an inch in thickness, yet having a highly jointed structure and cleavage, the planes of the joints not being exactly at right angles to the wall of the seam.

"(*k.*) A rock of singular appearance, which occurs in large masses among the refuse of the mine, being a mixture in about equal quantities of small masses of magnetic iron and cleavable green feldspar, from the size of a pin to that of a hazel nut, or larger. The contrast of colors produces a peculiar effect.

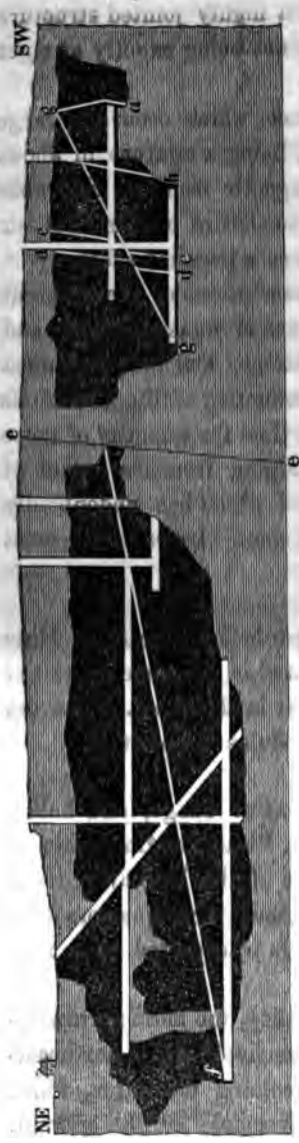
"It will be perceived from the descriptions of the different ores of this mine, that most of them are of unusual purity and freedom from the ordinary contaminations, and that they must therefore be eminently fitted for the production of the finer kinds of iron and steel wares. At the same time the quantity of these ores which have been taken away, judging from the extent of the excavation, and the greater part of which has undoubtedly been used for inferior purposes, or in short *thrown away*, must have been very great."

Richard Mine.—A few hundred yards from the Allen Mine is the Richard Mine, apparently situated in the same deposit of ore, which is here from three to five feet in thickness. The ore is finely granular, and contains small nodules of apatite.

Mount Pleasant Mine.—In the same range, and half a mile farther to the southwest, is the Mt. Pleasant Mine, which is situated in a low hill, near the junction of the Rockaway river, and the Burnt Meadow brook. It is about three-quarters of a mile from the canal, to which the ore is transported by a railroad.

There are three deposits at this locality, the most northwesterly of which has been worked very extensively at its northeastern part. The great difficulty in overcoming the water, which accumulates here on account of the looseness of the ground,

Fig. 1.



VERTICAL SECTION OF MT. PLEASANT MINE, OCTOBER, 1855.

made it necessary to abandon this part for the southwest end. The working of this and of the Byram Mine is very much encumbered by faults ("offsets".) In this mine there are five, which incline at an angle of about 75 deg. towards the northeast.

The first fault *a* (Fig. 1*,) is five feet. It is at a distance of eighty-five feet from the southwest end of the mine. From this, at a distance of forty-five feet, is a second fault *b*. The third fault *c* is broken by the cross slide or fault *g*, the lower part being one hundred and seventy feet from the southwest end, and the upper part one hundred and forty feet. At a distance of thirty-five feet, *d*, is the fourth fault, also broken by the cross slide *g*. At a distance of three hundred and fifty feet from the southwest end, is the largest and last fault, *e*. It is twenty feet, dividing the northeasterly and southwesterly workings.

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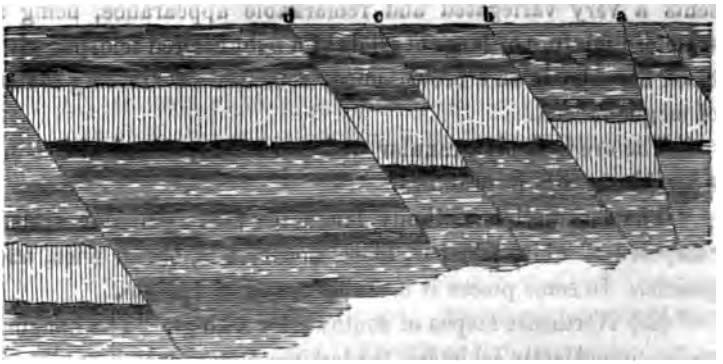
* This section is drawn to a scale of one hundred and sixty feet to one inch. The part in black represents the extent to which the ore has been removed; the horizontal lines represent the ore remaining; the heavy white lines the shafts and levels; and the light colored line shows the position of the faults.

"The position of these faults will be better understood by reference to the exaggerated horizontal section (Fig. 2*), in

FIG. 2.



HORIZONTAL SECTION OF MOUNT PLEASANT MINE, SHOWING FAULTS ("OFFSETS.")

which the same letters designate the same parts as represented in the vertical section (Fig. 1.) The extreme length of the workings in the southwestern end is two hundred and seventy-five feet, and the depth one hundred and forty feet. The thickness of the ore in this part is seven feet, and its average dip 50 deg. The working at the northeastern end has an extreme length of five hundred feet, and extends under the low ground at Burnt Meadow brook. The greatest depth at this end, which is at the pump shaft, is two hundred and twenty-five feet.

† "Specimens were collected of the hanging wall, foot-wall, and ore, at five places along the course of the ore-bed; namely, at the northeast stopes of the northeast workings or extreme northeastern limit of the mine; at the northeast stopes of the southwest workings; at the east and west offsets; and at the southwest stopes of the southwest workings, or extreme southwestern

* In this section, the seam of ore is represented by the short parallel lines running transversely to the section. The longitudinal scale is forty feet to one inch; the transverse scale twenty feet to one inch.

† From Mr. Wurtz's Report.

limit of the mine. A great number of highly interesting miscellaneous minerals were also found.

"(1.) Extreme northeast stopes. The hanging wall here presents a very variegated and remarkable appearance, being a schistose mixture of large crystals of a light colored feldspar with black hornblende and brown mica, sometimes containing seams of magnetic iron.

"The ore is finely granular and crystalline, mixed with considerable apatite in granules.

"The foot-wall is a thinly laminated finely granular schist, composed of white feldspar, black hornblende, brown mica, and quartz. In some places it contains seams of epidote.

"(2.) Northeast stopes of southwest workings. The hanging wall is imperfectly schistose, the laminæ being black hornblende, feldspar, and light brown altered mica.

"The ore is granular, with a few grains of a greenish decomposed mineral, which is not apatite.

"The foot-wall is an indistinctly schistose, finely granular mixture of green feldspar and translucent quartz.

"(3.) Extreme southwest stopes. The hanging wall is generally a highly crystalline mass of black hornblende, sometimes containing much feldspar, and sometimes mica and calcite. It has also frequent incrustations of calcite in fissures.

"The ore is granular and very nearly pure, containing in admixture a soft green mineral, which is probably a product of alteration of the hornblende of the hanging wall: and also sometimes incrustations of calcite in fissures. It contains also in places a few granules of apatite.

"(4.) The miscellaneous specimens comprise the following: A translucent massive quartz, which occurs in imbedded masses (small 'horses') in the ore. It is particularly interesting from containing occasional small bunches of chalcopyrite or copper pyrites.

"Apatite, or phosphate of lime, sometimes in masses six inches in diameter and having imperfect but continuous cleav-

ages, which pervade the whole mass, showing them to belong to large crystals. Several very perfect terminated crystals of apatite were also found. It is opaque and of reddish grey color, being sometimes associated with large crystals of black hornblende or irregularly mingled masses of quartz and magnetic iron. Most of the masses of phosphate of lime were found in a heap of fragments which appeared to have been taken out in excavating a shaft which has been sunk to the ore near the northeast extremity of the mine, and there may be a seam of the rock in this place containing a considerable quantity of this mineral.

"Irregular mixtures of large angular masses of granular magnetite and quartz cemented by white crystalline chalybite (spathic iron), with seams of pyrites running irregularly through the mass, containing also crystals of apatite several inches in dimensions, and forming very handsome specimens.

"A soft green mineral, columnar or subfibrous in structure, the fibres being brittle and sometimes six or seven inches long. The same mineral occurs also without the columnar structure, but apparently amorphous, and mixed with crystals of hornblende in seams in hornblende rock. Its constituents, according to analysis, are silica, lime, small quantities of magnesia and iron, with water. It is probably, therefore, a product of the metamorphosis of hornblende.

"Masses of black hornblende, with cleavage surfaces several inches across, found at the southwest extremity of the mine. A qualitative examination of this mineral indicates the presence of silica, iron, magnesia and lime, the quantity of lime, as for certain reasons I had anticipated, being apparently in much excess over the magnesia, thus making the mineral a lime hornblende. A quantitative analysis of this hornblende will be made.

"Specimens of a granular, crystalline, highly schistose rock, formed of apparently contorted laminæ of white feldspar, black hornblende and magnetic iron, the laminæ in one case being bent entirely double, a layer of magnetic iron appearing in the centre, with the others arranged concentrically around it.

"Seams and bunches of white crystallized chalybite, and ferriferous calcite, in quartz.

"Mixtures of apatite and quartz in large crystals, containing broad plates of hair-brown mica, in fissures in feldspathic gneiss. Two or three small crystals of zircon were also found at this mine.

"The feldspar crystals of this mine were examined to determine their species. Three cleavages were found, the two most distinct, O and *i* *i*, giving with the common goniometer an angle of 90 deg., thus making the mineral orthoclase. The third made with *i* *i* the angle 90 deg., and supposed therefore to be *i* *i*, but O : *i* *i* was found to be 121 deg. instead of 116 deg. 7 min., as it should be in orthoclase. The examination will be repeated."

Huff Mine.—The Huff Mine, which is next in a southwesterly direction from the last named, is not upon the same range, but a quarter of a mile northwest of it. There are three deposits here, all of which, although formerly more or less worked, are now abandoned. Near the Washington Forge pond, about a quarter of a mile from this mine, and like it aside of the general range, is the Burwell Mine, which is also abandoned.

The next deposits that occur in a southwesterly direction from this locality are those of Irondale, beginning within a quarter of a mile of the canal bank. On the first of these is the Harvey Mine, which has not been worked for several years; then succeeds the North River Mine, apparently upon the same deposit in which the Hubbard Mine is situated—a deposit remarkable for dipping at a lower angle than any other in this section, namely at 30 deg. The seam or deposit of ore is from two to eight feet in thickness, and has been worked to the depth of seventy feet. Southwest of this are the Stirling, Spring, and Sullivan mines.

The deposit of ore in which the Stirling mine is situated, is from six to sixteen feet in thickness, including several small

seams of rock ('horses'). It pitches beneath a capping of rock towards the northeast, and dips towards the southeast at an angle of 45 deg.

"Within a quarter of a mile of the Stirling, is the Corwin Mine, which like the Huff and Burwell Mines, is a short distance to the northwest of the regular range, apparently upon a different and parallel series of hills. The ore has been taken out on this deposit, for the distance of about three hundred yards. The workings at the northeast end extend to the depth of ninety feet, when they run out to the surface at the southwest end."

Mr. Wurtz has described the Corwin, Stirling, and Hubbard Mines as follows:

"Corwin Mine.—The seam of ore which dips to the S. E. at an angle of about 45 deg., is from five to eight feet in thickness. Two shafts have been sunk at this place, seventy-five feet apart, and the ore is opened to a depth of about one hundred feet. Specimens were procured at the bottom of each of these shafts, of the hanging wall, foot wall and ore.

"(1.) At the bottom of the N. E. shaft the hanging wall is a schistose, small granular rock, the laminæ of which are sometimes contorted. Its constituents are generally black hornblende, and a white or green feldspar, the latter predominating, with a little dark brown mica disseminated; some laminæ, however, consisting entirely of black hornblende, or of magnetic iron.

"The ore is apparently similar to that at the S. W. shaft, described below, but unlike that containing little or no pyrites intermixed, this latter being replaced by specks of limonite, or hydrated sesquioxide of iron, indicating the oxidation of the pyrites, and removal of the sulphur. Some specimens contain much phosphate of lime intermixed.

"The foot wall is a thinly laminated, coarsely crystalline schist, composed of quartz, green feldspar and black mica, in-

termixed in places with much magnetic iron; sometimes partially decomposed.

"(2.) At the bottom of the southwest shaft, the hanging wall is coarsely schistose and small granular in structure, composed of quartz and green feldspar, the latter predominating in quantity. Some laminæ contain much magnetic iron.

"The ore is finely granular and crumbly, ('shot ore') containing disseminated specks of pyrites, and numerous small specks of phosphate of lime.

"The foot wall is small granular and highly schistose, composed of a white feldspar, black or brown mica and black hornblende, with a few specks of pyrites, and in some places much magnetic iron.

"Stirling Mine.—It is one of the most important mines in this section, and has been and still is very productive of ore. The seam of ore is irregular in width. The workings extend along the seam for a distance of three hundred feet, and at the deepest part of the mine, which is at the middle stopes, the ore has been exposed to a depth of one hundred feet from the surface. The strike of the seam is as usual about N. E. and S. W., and its dip, following that of the beds of gneiss between which it is interposed, is variable, being in some places 45 deg. or more, while in others not more than 30 deg. Specimens were collected of the ores at the two extreme ends of the mine, as well as in the middle stopes, or deepest part of the mine, together with the adjacent walls, wherever it was possible, the foot walls at the N. E. and S. W. stopes being inaccessible at the time of my visit; also of a 'horse' which occurs here.

"(1.) At the extreme N. E. workings the hanging wall is a highly decomposed schistose rock, composed of small grains of feldspar, with some quartz and a few grains of magnetic iron intermixed.

"The ore is very crumbly, granular ('shot ore'), much stained

with limonite, and mixed with very much of a pulverulent white substance, which is apatite in a highly altered state. It has a jointed structure, and a very feeble, scarcely perceptible polarity.

"(2.) At the middle stopes, the ore is a mixture of granular magnetic iron with much phosphate of lime in granules and nodules. It partakes very highly of the character of 'shot ore,' being easily crumbled to a coarse powder between the fingers, although apparently compact in the mass, and presenting no indications of the least decomposition. It has an imperfectly jointed structure and is feebly polaric, though more so than the ores from the two extremes of the mine.

"(3.) At extreme S. W. workings. The ore is precisely similar to that at the other end of mine, though probably less impure, and not so much decomposed.

"(4.) The 'horse' is a rock of peculiar appearance. It is strongly schistose in structure, some laminæ being composed of coarse crystals of feldspar of a dark color, black hornblende and magnetic iron; others of a mixture of feldspar, quartz and magnetic iron; others still of a mixture of magnetic iron with a very large proportion of phosphate of lime, the latter forming more than half the mass. In this rock were observed imbedded masses in the form of rounded nodules, apparently feldspar, and having a distinct cleavage, resembling those found at the Mount Hope Tunnel.

"Hubbard Mine.—The seam of ore is but from four to four and a half feet thick, its course being about as usual, N. E. to S. W., but its dip much less than usual, or only 30 to 35 deg. from the horizontal. Specimens were obtained of the hanging wall, foot wall and ore.

"The hanging wall is a coarsely schistose mixture of large crystals of quartz, magnetic iron and hornblende, the latter min-

eral predominating, and the two latter somewhat altered by oxidation.

"The ore is a granular mixture of magnetic iron and phosphate of lime, the granules of both being very small. It has a jointed structure.

"The foot wall is a coarsely crystalline mixture of quartz and feldspar, the latter predominating; sometimes intermixed with magnetic iron. The schistose structure is not apparent."

About a quarter of a mile southeast of the Stirling Mine, is the Jackson Mine, and about a quarter of a mile southwest of the Jackson Mine, is the Randall Hill Mine, situated apparently in the same deposit, the latter being somewhat nearer the summit of the hill. While at the Randall Hill workings there are two deposits, only one has been opened upon at the Jackson Mine. At Randall Hill, the workings were the more extensive of the two, and at one time a steam engine was employed to pump water here through a shaft nearly three hundred feet in depth. Both of these mines are, at present, abandoned.

In a southwesterly direction, at the distance of a quarter of a mile from the Randall Mine, and about one hundred yards south of the road from Dover to Stanhope, is the MELLEN MINE. This mine has been also, for the present, abandoned.

The following are extracts from the report of Mr. Wurtz:

"The seam has been worked from northeast to southwest about forty-five yards, and throughout this distance it preserves, like that of the Byram Mine, considerable regularity of form, being usually about two feet thick near the surface, and gradually widening to five feet towards the bottom, the mine being about one hundred and thirty feet deep. The dip is towards the southeast, as usual, and very steep. The specimens collected were as follows:

"(1.) The hanging wall at the extreme northeast stopes of

the mine; a mixture of partially decomposed feldspar with quartz, containing considerable magnetic iron.

"The ore at the same place, which is heavy, of columnar structure, and contains interspersed nodules of altered apatite.

"The foot-wall at same place; very similar to the hanging wall, but contains less quartz and magnetic iron, and is more decomposed.

"(2.) A small 'horse' found in the seam of ore; a fine-grained mixture of light bluish feldspar with small quantities of black mica, quartz and magnetic iron. It is not so much decomposed as most of the other rocks found at this mine.

"(3.) The wall of a small 'offset,' or fault in the strata, which displaces the seam of ore a few feet, and which is composed of a decomposed feldspathic gneiss.

"(4.) The hanging wall in extreme southwest stopes; a mixture of bluish feldspar, partly decomposed mica, and magnetic iron.

"The ore in same place; mixed with altered apatite and other minerals, and containing seams of decomposed hornblendic gneiss.

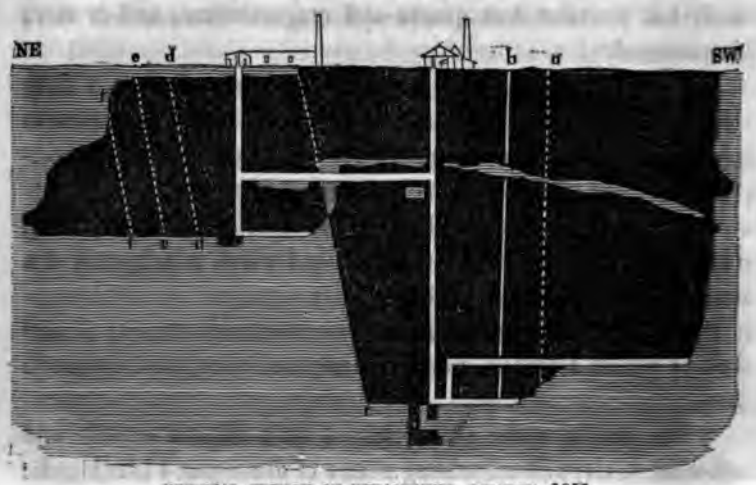
"The foot-wall at same place; a mixture of feldspar with small scales of black mica. Very much decomposed, much more than the hanging wall.

"Miscellaneous specimens, comprising crystalline mixtures of feldspar with quartz and magnetic iron, the latter frequently oxidized or partially so, and sometimes in the form of seams traversing the rock, which show very well the junction of the ore and rock, the two being much mixed at the point of juncture; also a schistose rock composed of white altered feldspar and quartz, with seams and bunches of magnetic iron, some laminæ containing decomposed brown mica."

Byram Mine.—On Mount Ferrum, about five hundred yards southwest of the last mentioned mine, is the Byram mine. This

deposit of ore, although more regular than most of the deposits in this metalliferous belt, is very much dislocated by faults ("offsets"). The accompanying vertical section (Fig. 3) repre-

FIG. 3.



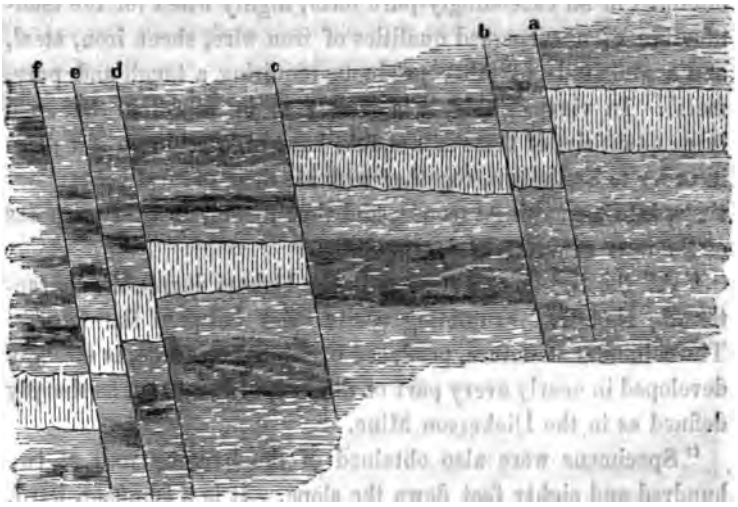
VERTICAL SECTION OF BYRAM MINE, OCTOBER, 1855.

sents the extent to which the deposit has been worked. The inclined plane at the southwestern end is two hundred and sixty-eight feet in length, and, as the dip of the deposit is 50 deg. this makes the bottom of the mine about two hundred feet below the surface. This end of the mine is separated from the northeast end by a fault of fourteen feet, and has been worked for a distance of three hundred and thirty feet southwest of it. The north end has been worked from the fault for a distance of two hundred and fifty feet.

The faults in this mine are six in number. The first *a* (Fig. 3), at the distance of one hundred and thirty feet from the southwest end of the mine, throws off the deposit five feet to the north-

west; the second *b*, thirty-six feet from this offset, throws it off one foot and a half in the same direction; the third *c*, one hundred and fifty-three feet from the second, throws it off fourteen feet; the fourth *d*, one hundred and ten feet from the third, throws it off six feet; the fifth *e*, twenty-nine feet from the fourth, throws it off five and a half feet; and the sixth *f*, twenty-seven feet from the fifth, throws it off eight feet, which is exactly the thickness of the deposit. The letters on the horizontal section (Fig. 4) refer to corresponding parts in the vertical section.

Fig. 4.



HORIZONTAL SECTION OF BYRAM MINE, SHOWING THE POSITION OF THE FAULTS ("OFFSETS").

This mine is one mile and a half from the point on the canal at which the ore is shipped.

Extract from Mr. Wurtz's report:

"The ore of this mine appears to contain, on an average, more apatite than that of the Dickerson Mine, and specimens were frequently met with which seemed to contain more of this mine-

ral, in bulk, than of magnetic iron, although of course much less in weight. Specimens of the ores were obtained from the lowest workings, two hundred and eighty feet down the slope, comprising average samples of the ore, which seemed to be granular mixtures of magnetic iron and apatite, and of the picked ore, which was the same, except in containing less apatite. A great deal of this picked ore might be considered as very nearly pure magnetite, and there can be no doubt that by proper processes of washing, or treatment by magnetic machines, a large proportion of this ore, as well as that of the Dickerson Mine, might be obtained in an exceedingly pure form, highly fitted for the manufacture of unsurpassed qualities of iron wire, sheet iron, steel, and a multitude of other products requiring a tough and pure, metal. In view of this, it is greatly to be regretted that such large quantities of these ores should have been sold at a low price in order to be thrown, together with all their natural contaminations, into a smelting furnace, and thus forever lost for purposes of the finer manufactures.

"All the Byram ores possess in the highest degree the character of 'shot ore,' crumbling easily even between the fingers. The columnar structure, produced by jointed cleavage, is strongly developed in nearly every part of the bed, although not so sharply defined as in the Dickerson Mine.

"Specimens were also obtained of the hanging wall at two hundred and eighty feet down the slope. It is a compact, hard, crystalline granular rock, composed principally of a greenish feldspar, with disseminated particles of magnetic iron, and of pyrites, and sometimes some specks of a hair-brown mica; also of the foot-wall at the same point, which is similar in appearance, except that it contains no pyrites; also of a small 'horse' which penetrates the bed at the southwest workings, which is composed of a coarsely crystallized mixture of greenish feldspar and magnetic iron, sometimes subschistose in its structure; also

of the ore taken from one of the columns left to support the hanging wall, at eighty feet down the slope, which is much purer than that at the bottom of the mine, but is much mixed with the remains of decomposed feldspar, and superficially stained brown by limonite."

Brotherton Mine.—About a quarter of a mile further to the southwest is the Brotherton Mine, which is not at present in operation.

Extract from Mr. Warts's report:

"No machinery for draining having been erected, the formation has not yet been penetrated to a sufficient depth to show its structure with any reliable accuracy. Specimens were collected of the hanging wall, foot-wall, and ore.

"The hanging wall is a slightly decomposed hard feldspathic schist, containtng some quartz, and interspersed with grains of magnetic iron ore.

"The ore is a mixture of magnetic iron, with much decomposed feldspar.

"The foot wall is similar to the hanging wall in appearance, but more schistose, less compact, and more finely granular in structure, and much more decomposed."

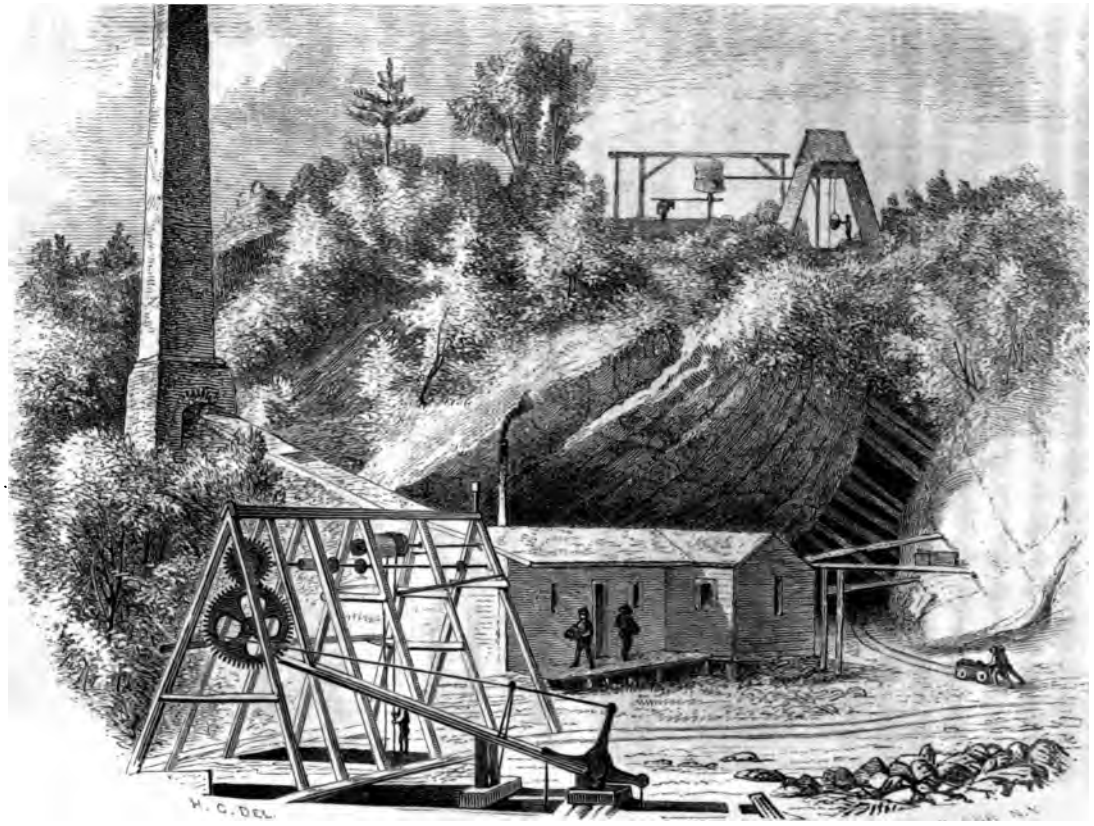
Dickerson Mine.—In the order of distance, though not of range, the Dickerson Mine is next to that last mentioned; and like some others already noticed, it is situated one third of a mile northwest of the general direction of the series. This mine is said to be the oldest in the iron region of Morris County; and has been celebrated throughout the State for furnishing a superior ore for forge purposes. The tract of land including the mine was taken up as early as 1713, by Joseph Kirkbride. In 1807, the late Hon. Mahlon Dickerson became its owner, and worked it until the time of his decease, three years ago. In 1853, the Dickerson Succasunna Mining Company purchased it,

and have erected a steam engine, and made other preparations for the most extensive operations. The accompanying view and

Fig. 5.

VERTICAL SECTION OF DICKERSON MINE, OCTOBER, 1855.

section will give some idea of the appearance on the surface, as well as the extent of the underground workings. The view represents the outcrop of the ore deposit, the stratification of the hanging wall rock, the engine house, horse whim, and machinery for pumping and hoisting. The section exhibits the extent of the underground workings. The deepest part of the mine (N. E. workings), called the "old mine," has been abandoned. It was worked by three shafts, sunk to the depth of about two hundred feet below the present surface, which, at this point, is about twenty five feet lower than the original surface of the hill. These workings are two hundred and seventy three feet in extreme length on the bottom. The ore, in some places, in this part of the mine, measures thirty feet in thickness; but at the extreme northeastern brest, it is only three feet. That part of the mine which is at present worked, has been sunk to the depth of about one hundred and seventy feet below the surface. At this depth, the shaft has not struck the "horse" *c*, the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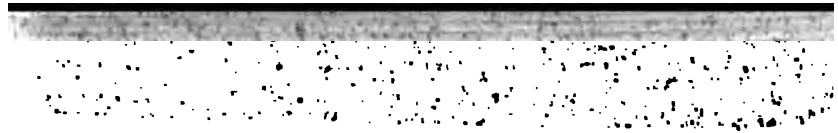


distance from the bottom of the shaft to the "horse," as at present exposed, being forty feet. The thickness of the ore at the northeast brest *b* of this part of the mine, is also three feet; the greatest thickness at *z* is thirty feet. Four or five shafts have been sunk on the outcrop of this deposit, at the top of the hill, but none of these workings are of much extent. This deposit of ore, like many others described in the preceding pages, pitches beneath the rock towards the N. E., while its S. W. extremity is underlaid by it.

Extracts from Mr. Wurtz's report:

"There is here an immense, somewhat irregularly shaped cake or lenticular mass of magnetic iron ore, lying imbedded in the gneiss rock, its longest diameter coinciding both in strike and dip with the direction of the bedded structure or stratification of the gneiss. In the direction of this longest diameter it thins out, at nearly every point where its limits have been reached, to acute edges, such edges being sometimes split into two by wedge-formed masses of the rock, which sometimes penetrate to a considerable distance into the mass of the ore, thinning out also usually to acute edges. These interpenetrating masses of rock are called, in the language of the miners, 'horsers,' or 'horses,' probably from some occasional fanciful resemblance of their upper acute edges to a horse's back. The direction of their longer diameter is usually parallel to the stratification or schistose lamination of the rock forming the walls of the mass of ore, and therefore parallel also to that of the ore itself. They frequently have well defined walls on their sides, the rock forming the horse not being mixed with the ore in which it is imbedded, nor the ore mixed with the minerals forming the rock of the horse, at the point where they come in contact. The mass of ore, especially in places where it is thin, or where the walls approach each other, has frequently a jointed or columnar structure, the directions of the planes of the joints being at right angles, or nearly so, to the walls, and crossing one another at various angles.

Some measurements were made of these angles between the planes of the joints with a Hauy's goniometer, and gave 77¼ deg., 105½ deg., 110½ deg., 94 deg. This jointed structure is, generally speaking, most highly developed where the ore is most free from impurity. The appearance of the great mass of the ore of this mine is that of a very pulverulent, though closely compacted mixture of small irregularly angular grains of magnetic iron ore, or magnetite, with small rounded granules of phosphate of lime or apatite. Such ore is called by the miners 'shot ore,' from its crumbling easily into small fragments from the size of a small shot up to that of a pea. This property is not to be attributed to any effect of partial decomposition, for ore which has apparently never been subjected to the action of water or air, possesses it. The proportions of the two principal ingredients of the ore are very variable, but the phosphate is always the smaller in quantity. Its average proportion, as shown by a partial analysis that has been made, is between nine and ten per cent. The ore is very rarely found in crystals. A single specimen containing distinct octahedrons, with much striated faces, was found imbedded in a soft green mineral of columnar structure, occurring in a seam in the foot wall, near the principal entrance to the mine.

"As before remarked, the general inclination of the bed of ore is that of the beds of the surrounding gneiss rock, which is here usually at a steep angle to the S. E. The wall of rock on the S. E. side of the ore is accordingly called by the miners, the 'hanging wall,' and that on the N. W. side the 'foot-wall,' as is done in the case of regular metalliferous veins, which this formation does not in any other respect resemble; but the terms being nevertheless convenient, and not particularly objectionable, we shall adopt them. The inclination of the ore-bed follows the contortions and irregularities of the gneiss; thus, in some places, the axis of the deposit, instead of dipping to the S. E., is more nearly vertical, and even dips sometimes to the N. W. On au-

thority of the gentlemen in superintendence of the mine, Mr. Canfield, it may be stated that the ore upon the side of the bed nearest the 'foot wall,' is usually the purest. The general course of the horizontal axis of the ore bed is very accurately N. E. and S. W., or parallel to the upturned edges of the beds of the metamorphic schists all through this part of the State.

"From this mine were collected for the various cabinets, suites of specimens of the ore now being taken out, with specimens of ore showing the jointed structure, and of several other varieties; of the hanging wall, foot-wall, and a large 'horse,' which penetrates the mass of ore in the S. W. workings, at a place where it is more than thirty feet thick. This spot is about one hundred and eight feet below the surface, in the S. W. workings, near the point where the ore is at present being taken out, from which point the other specimens above mentioned were taken. Specimens also of hornblende and various other miscellaneous minerals were selected.

"The hanging wall is a rock composed of a mixture in about equal proportions of feldspar and quartz, in small grains.

"The average ore has already been described, as also that showing the jointed structure most strongly.

"The foot wall is a mixture of hornblende, feldspar, dark colored mica and quartz, the two former much decomposed.

"The 'horse' is very similar to the hanging wall, but somewhat more finely grained.

"The miscellaneous specimens, which are not particularly interesting at this mine, comprise crystals presenting large cleavage surfaces, frequently several inches long, and one inch broad, which are supposed to be hornblende, but have a very much less hardness (possibly proceeding from alteration); also different varieties of schistose rocks, one of which is a mixture of a dark olive-colored mica, with much apatite, magnetic iron, and incrustations of a transparent or translucent soft green mineral, which contains silica, lime, a little magnesia and sesquioxide of iron,

with water; another is composed of layers of magnetic iron, alternating with brown mica, and containing nodules of quartz. There are also mixtures of brown and brownish-olive mica with hornblende, the latter somewhat decomposed; and specimens of hornblendic gneiss, containing magnetic iron, which are incrusted with a brown substance, of crystalline appearance under the magnifier, and which, according to analysis, appears to be a hydrated silicate of magnesia, stained by manganese."

King Mine.—A quarter of a mile to the southwest of the Dickerson Mine, is the "King Mine," which is opened to the depth of thirty feet. The hanging wall rock here is gneiss, distinctly stratified, and composed of quartz and feldspar. Three layers of ore are exposed, each one separated from the other by layers of rock, as follows:

1st, a layer of ore four feet thick, highly magnetic, columnar, and containing apatite; 2d, intervening rock, micaceous slate in thin laminæ; 3d, ore eight feet thick, and of the same character as that of 1; 4th, rock in laminæ composed of feldspar, quartz, and a small quantity of mica; 5th, ore, feldspar, and quartz in admixture; 6th, foot-wall. The dip of the deposit is 54 deg.; its strike N. E. by S. W.; its pitch towards the N. E. at 50 deg.

The view on the next page represents the relative position of the two upper layers of ore, with the intervening rock and wall rocks. It also exhibits the columnar structure of the ore, and the stratification of the rock.

Logan Mine.—The last deposit in this range that has been worked to any great extent, is on the property of Mr. C. S. Dickerson, and was formerly designated as the Logan Mine. It is about two and a half miles from the Dickerson Mine, in a southwesterly direction. There are two deposits here, fifty feet apart, of which the larger, or southwesterly, only, has been

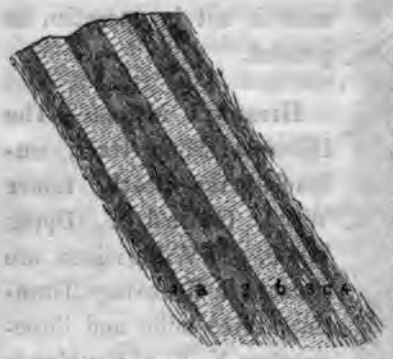
worked. The workings are about fifty feet deep, and two hundred feet in length; and the thickness of the ore is from seven to nine feet. This mine is not in operation at present.

Hibernia Mines.—The Hibernia Mine tract, embracing the Beach, Lower Wood, Glendon, Upper Wood, and Willis mines, are situated in Rockaway Township, three miles and three-quarters N. E. of the Morris Canal, at Rockaway. It is one of the oldest mine tracts in the State, and from the earliest settlement of this section of the Highlands, to the present time, it has supplied numerous forges and furnaces throughout the country with ore, which has been manufactured into almost every variety of article for which this metal is used.

The principal deposit in which these mines are situated, is the most regular and uniform, both in regard to its dimensions and the character of its ore, that has been exposed within the metalliferous belt of the Highlands. It crops out on the summit of a ridge, which, commencing at its southwestern extremity, at the Hibernia brook, rises first abruptly, and then gradually, to the height of three hundred and eighty feet. This deposit has been worked to a greater or less depth, as shown in the accompanying

section, for a distance of nearly a mile. (See map.*) It is composed of two, and in some places three distinct layers of ore interstratified with micaceous and hornblende schists, of the following character:

Fig. 6.



Commencing at the base of the ridge at Hibernia brook, Fig. 6 represents a transverse section in the adit end, one hundred and fifty feet from its entrance, dipping southeast at an angle of 60 deg. The layer *a*, varying from three and a half to five feet in thickness, is a coarsely granular magnetic iron ore, possessing polarity, columnar in structure, and containing, disseminated throughout it, imperfect crystals of apatite, and dark green hornblende. *b* is three feet thick, and differs from *a* in that it contains less apatite. The ore *c* is from ten to twelve inches thick, and is almost entirely free from foreign minerals, possessing a highly crystalline columnar structure. The rock 1, constituting the foot-wall of the deposit, is a crystalline hornblende schist, composed of black hornblende, greenish feldspar, minute grains of magnetic iron ore, and hexagonal scales of brown mica, and in some places is interspersed with iron pyrites in grains, nodules and bands. The layer of rock 2, separating the ore *a* and *b*, is

* The location and boundaries of the different mine lots into which this tract has been divided, and which have given origin to the various names by which they are designated, are represented in the map and accompanying section. The dotted contour lines, representing the margins of a series of imaginary horizontal planes, intersecting the mountain at vertical intervals of six feet, show the form and height of the mountain. A B represents the outcrop of the ore deposit. In the section, the heavy black lines represent the shafts and levels; the inclined parallel lines represent the ore already removed, and the white portion the ore still remaining.

from two and a half to three feet thick, and is a friable schist, composed of greenish feldspar, black hornblende, and brown mica. These minerals are variously associated; in some places occurring in large crystals, and irregularly mixed; again in small irregular grains, interlaminated with each other, forming a perfect schist; and in other places, as on the summit of the ridge between the Glendon and Upper Wood mines, occurring in large, irregular masses, varying from half an inch to more than a foot in diameter, of pure feldspar, quartz, mica and granular magnetic ore. The layer of rock 3 is from sixteen inches to two feet thick, and is a hornblende schist, simliar to the rock 2, both in its structure and composition. The rock 4, constituting the hanging wall of the deposit, is a fine grained, hard, crystalline hornblende schist, composed of black hornblende, white feldspar, and quartz, containing sparingly, in admixture, small scales of brown mica, and minute grains of magnetic ore.

Fig. 7.

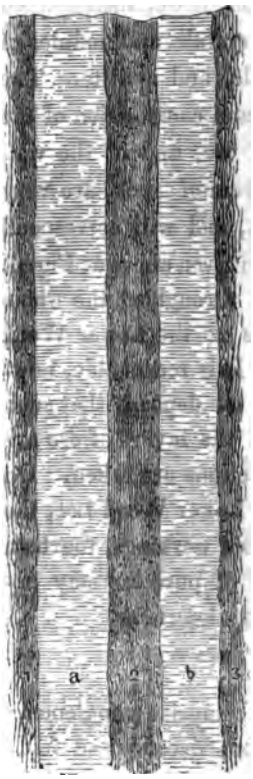


Fig. 7 represents a transverse section of the deposit in the Glendon Mine, about half way between the extreme northeast and southwest workings, or midway between the Lower Wood and Willis mines. Two layers of ore, *a* and *b*, are here exposed, *a* being eight feet, and *b* six feet in thickness, and separated by a layer of hornblende schist five feet thick. This ore dips to the southeast, at an angle of 86 degrees, and has been worked to the depth of one hundred and twenty-five feet.

Fig. 8.

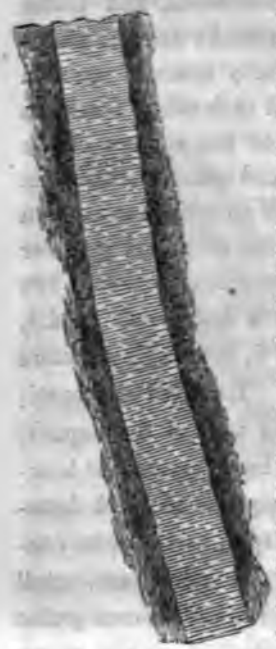


Fig. 8 represents a section of the deposit at the most northwesterly workings, at the Willis Mine. The ore dips, first, at an angle of eighty-one degrees, and again, about thirty feet from the surface, at an angle of seventy-three degrees. Only one layer of it has been exposed and worked, the average depth of which is sixty-five feet, with an average thickness of seven feet. This ore is granular and very friable, columnar in structure, and highly magnetic, interspersed throughout with crystals and nodules of greenish hornblende, and apatite. The general character and composition of the different layers of ore, and of the wall and intervening layers of rock, are very similar throughout, and will correspond with the description given above at Fig. 6. Whether these three layers of ore extend throughout the whole deposit, and are of the same character as at the Lower Wood Mine, is not yet positively determined. It is reasonable, however, to infer, from the great regularity of the deposit, that such is the case. In some parts of the deposit the layers of ore are much thicker than those from which the sections are taken. On the southwestern slope of the ridge, on the Lower Wood Lot, the ore of the three layers is exposed in the old workings, fourteen feet in thickness. How far this thickness of pure ore may extend, future explorations and workings must determine.

Extract from the report of Mr. Wurtz:

"Miscellaneous Specimens.—These comprise conglomerates of angular fragments of magnetic iron, decomposed feld-

spar, mica, etc., with cavities filled with botryoidal crystallizations of pyrites, (these conglomerates are similar to those described as occurring at the Allen Mine, but the cementing material in this, instead of chalybite, is merely calcite, somewhat ferriferous); crystals of feldspar, which when broken across, present in section zones of different colors, such as white, greenish and violet, proceeding from different degrees of alteration in composition, by the action of water and air, associated with small hexagonal prisms and plates of mica (phlogopite ?); seams of white calcite in micaceous schist, which contain transparent green and violet fluor spar, of beautiful tints, and crystals of quarts in the form of regular double hexahedral pyramids; a rock composed of nearly pure black hornblende in large crystals; mixtures of salmon-colored feldspar and green hornblende in large crystals; small hexagonal plates and prisms of hair-brown mica, associated with quartz and green needles of tremolite, in seams of altered feldspar in magnetite; crystalline nodules of apatite, half an inch in diameter, in magnetite; white incrustations on gneiss, with a soapy feel, but containing much carbonic acid; chalcopyrite associated with the above described variegated feldspar and hexagonal plates of mica in magnetite; seams of a flesh-colored calcite, presenting curved cleavages, in hornblendic schist. One crystal of sphene, about three-fourths of an inch in diameter, was found imbedded in calcite, and associated with the angular cemented masses of magnetite above spoken of. It gives the reactions of titanic acid before the blow pipe. It appears to be somewhat altered, and few of the faces possess their original polish, so that satisfactory measurements could not be made of the angles."

The accompanying map, profile and sections, show the position and extent of the deposit, as far as it has been worked above water level, also the manner in which it as been mined, and the extent to which the ore has been extracted; although in a great-

er part of the workings, only one of the layers has been removed, leaving one, and, in some places, two layers still unworked.

This deposit has not, as yet, been mined as it should be, because of its many divisions into mining lots controlled by different persons. The upper mines of the tract, viz: Glendon, Upper Wood and Willis, are worked by means of shafts sunk into the deposit, through which the ore, as well as the water, is raised. This mode should be resorted to, especially when the price of iron is so low, only in those cases where the position of the deposit will not admit of an adit level, through which the ore and water may be removed without the expense of machinery, for hoisting and pumping, which often increases the cost of mining a ton of iron to its full value.

The key or great outlet to this large and valuable deposit of ore, is the Lower Wood Mine, situated on the southwestern slope of the ridge. By means of levels driven into the deposit from this slope even with the water level, and connected together by shafts and winzes, for ventilation, and passage ways for ore, from a higher to a lower level, this whole deposit, above water level, might be removed and landed at the foot of the slope, without the great expense of hoisting and pumping.

A railroad route has been surveyed and located, which extends from the canal, at Rockaway, to the Lower Wood Mine, three miles and a quarter in length, and with a gentle grade, the adit level of the Wood being but forty-seven feet above the canal. Thus it will be seen that this tract possesses unusual advantages for extracting the ore from the deposit, as well as for transporting it to the banks of the Morris Canal, one of the principal channels of communication with the iron smelting and manufacturing works in this State and Pennsylvania.

Beach Mine.—This mine, although it is generally included among the mines of the old Hibernia Mine tract, the general character of its ore and wall rocks being the same, is situated

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the possession of Dr. C. Beach, who has worked it to the present time, and removed therefrom three thousand tons of ore, the greater part of which has been manufactured into blooms at the

Fig. 8.

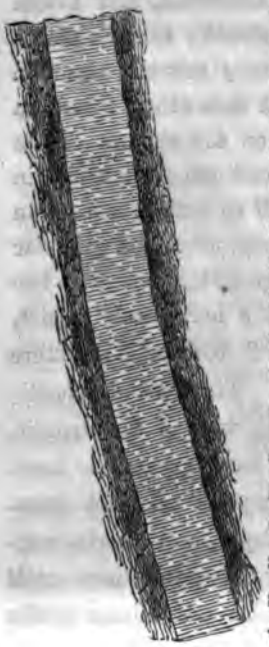


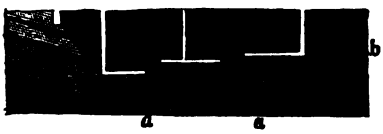
Fig. 8 represents a section of the deposit at the most northwesterly workings, at the Willis Mine. The ore dips, first, at an angle of eighty-one degrees, and again, about thirty feet from the surface, at an angle of seventy-three degrees. Only one layer of it has been exposed and worked, the average depth of which is sixty-five feet, with an average thickness of seven feet. This ore is granular and very friable, columnar in structure, and highly magnetic, interspersed throughout with crystals and nodules of greenish hornblende, and apatite. The general character and composition of the different layers of ore, and of the wall and intervening layers of rock, are very similar throughout, and will correspond with the description given above at Fig. 6. Whether these three layers of ore extend throughout the whole deposit, and are of the same character as at the Lower Wood Mine, is not yet positively determined. It is reasonable, however, to infer, from the great regularity of the deposit, that such is the case. In some parts of the deposit the layers of ore are much thicker than those from which the sections are taken. On the southwestern slope of the ridge, on the Lower Wood Lot, the ore of the three layers is exposed in the old workings, fourteen feet in thickness. How far this thickness of pure ore may extend, future explorations and workings must determine.

Extract from the report of Mr. Wurtz:

"Miscellaneous Specimens.—These comprise conglomerates of angular fragments of magnetic iron, decomposed feld-

three-quarters of a mile southwest of the Lower Wood Mine, on a ridge that rises abruptly from the northeast, to a height of five hundred and twenty feet above Hibernia brook. The outcrop of the deposit of ore is situated in the northwestern slope of the ridge, twenty feet below its summit. The deposit averages three and a half feet in thickness, and dips at an angle of 80 degrees. It is a hard, coarse grained magnetic ore, interspersed with nodules and imperfect crystals of apatite and greenish hornblende. The general character of the wall rocks is a hornblende schist, varying considerably in structure and composition. A light green asbestus, in fibres of several inches in length, occurs frequently in the hanging wall rock adjacent to the ore. Calcite in seams, and crystals (dog tooth spar) occur, associated with black hornblende and greenish feldspar. The accompanying section, (Fig. 9), represents the extent of the workings, and the location of the faults. The ore has been removed in the deepest shaft, to the depth of fifty-five feet, and one hundred and ninety feet on the outcrop of the deposit. The layers of ore and wall rock have been dislocated. The lines *a a* show the position and extent of a fault that has shifted the deposit two feet towards the northwest, and the line *b* represents the angle at which the ore pitches beneath the rock towards the northeast.

Fig. 9.



VERTICAL SECTION OF BEACH MINE, OCTOBER, 1855.

This ore was discovered about seventy years ago, and the discovery led to the location of the mine lot and the working of the deposit to the depth of ten or twelve feet. About twenty-five years ago it was worked by Captain William Scott, to the depth of twelve or fifteen feet; and two years ago it came into the possession of Dr. C. Beach, who has worked it to the present time, and removed therefrom three thousand tons of ore, the greater part of which has been manufactured into blooms at the

forges in the vicinity, and the remainder sold as furnace ore. The blooms have been manufactured chiefly into hoop iron.

Beachglenn Mine.—This mine is situated on the northeastern border of Beachglenn pond, about one mile southeast of the Hibernia Mine tract. It was opened about sixty years ago, and worked only a few feet in depth and upon the surface. Four years ago the work was resumed, and carried to a considerable extent, exposing the layers of rock and ore in two different localities, viz: 1st, in what is known as the Southwesterly opening, which is situated on the border of Beachglenn pond, and has been worked three hundred feet on the deposit, and fifty feet in depth. The annexed transverse section (Fig. 10), shows the relative position and character of the layer of rock in which the ore is found; *a* is a hard, compact laminated rock, composed of quartz and feldspar, interspersed sparingly with grains of magnetic iron ore and scales of brown mica, and is transversed by numerous joints at right angles to the planes of lamination; *b* and *d* are schists composed of white feldspar, black hornblende, brown mica, and grains of magnetic iron ore, in about equal proportions, sparingly interspersed with small imperfect crystals of quartz; *c* is the layer that has been removed for its ore. It is a coarse, granular rock, averaging five feet in thickness, and composed of white feldspar, black hornblende, brown mica, and magnetic iron ore; the latter generally predominating over the other constituent minerals; *e* is a hard feldspathic schist, containing hornblende and magnetic iron ore in admixture; the mica entering but sparingly therein. The strata are very much curved and contorted; that which contains the

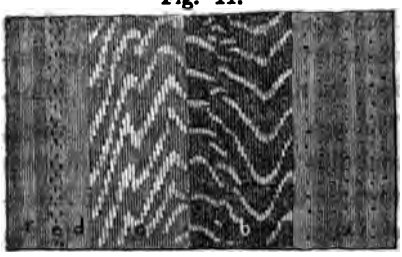
Fig. 10.

TRANSVERSE SECTION OF BEACHGLENN MINE, SOUTHWESTERN OPENING.

greatest proportion of ore, dips at the surface towards the northwest; but, twenty-five feet below the surface, it curves and dips slightly to the southeast.

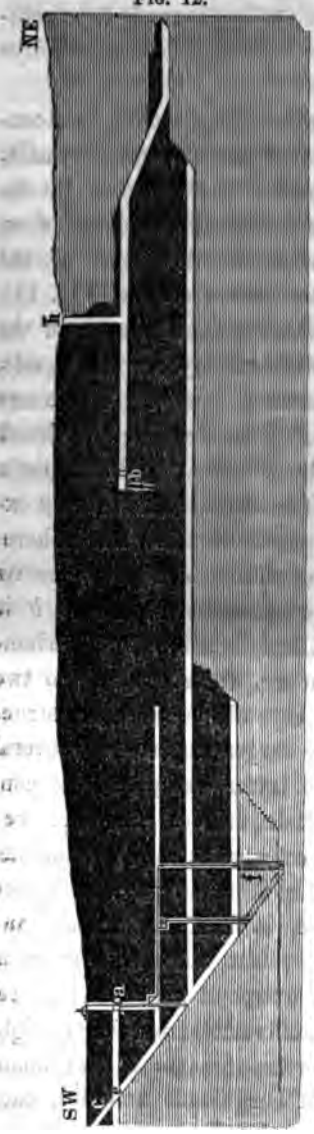
2d. The northeastern opening is situated apparently in a continuation of the same deposit, about four hundred yards from it. The ore here possesses the same general character as in the other opening, and affords the same indubitable evidence of an aqueous origin, contemporaneous with the deposition of the rocky strata. The accompanying transverse section (Fig. 11), exhibits the character of the different layers; *a* is a soft, coarse, granular admixture of white feldspar, black hornblende, and magnetic iron ore, which, on being exposed to the atmosphere crumbles and sets free its constituent minerals; *b* is composed of quartz, feldspar, and a little hornblende, interlaminated with bands of magnetic iron ore, from one-half to two inches thick. It possesses a highly crystalline, columnar structure, as distinctly marked as in the larger deposits, of several feet in thickness; *c* is similar to the latter, except that it contains a greater proportion of hornblende, and less magnetic ore; *d* is composed of quartz, feldspar, and magnetic ore in laminæ, varying from half an inch to an inch in thickness; *e* is composed chiefly of quartz and magnetic ore, in irregular masses and nodules; *f* is composed of feldspar, quartz, and magnetic ore in distinct laminæ. The portion of the deposit that has been removed, is represented at *c* and *d*, and varies from five to eight feet in thickness. Its average proportion of magnetic ore is about one-third; of feldspar one-third; of hornblende and mica each one-sixth. Its crumbling is due to the decomposition of the feldspar. The deposit is nearly vertical, dipping, near the sur-

Fig. 11.



TRANSVERSE SECTION OF BRACHBLEEN MINE, NORTHEASTERN SECTION.

Fig. 12.



VERTICAL SECTION OF SWEEDS MINE, OCTOBER, 1855.

face, slightly towards the northwest, but, a few feet from the surface, curving towards the southeast. It has been worked to the depth of twenty feet, and three hundred on its line of bearing.

Kitchell and Muir Mines.—Three quarters of a mile southwest of the Beach Mine, on the same ridge, occur the Kitchell and Muir Mines, the general character of the ore and wall rocks of which are similar to those of the Beach Mine. The ore deposit is two feet thick, and dips at an angle of 75 degrees towards the southeast. The Kitchell Mine has been worked to the depth of one hundred and thirty feet, and upwards of two hundred feet on the deposit.

Sweed's Mine.—Three miles southwest of the Kitchell Mine is the Sweed's Mine. It is situated on the bank of the Morris Canal, one mile east of Dover. The outcrop of the deposit of ore is on the southeastern slope of a hill; the highest point of this outcrop being seventy feet above the level of the water in the canal. There are two adits to this mine, *a* and *b* (Fig. 12), entering the side-hill at a distance of about one hundred yards from the canal, and being at their entrance,

one seven, and the other thirteen feet above it. They cut the deposit thirty, and sixty feet, respectively, below the surface; that at *a*, however, being connected with the plane, is the one used at present in taking out the ore.

The workings at this mine are rather extended than deep, the ore having been removed from the whole length of the deposit, as the workings were extended downwards. The northeastern brest has been driven to a distance of six hundred and eighty feet from the plane, and a gallery has been driven back of the plane, in an opposite direction, for a distance of one hundred and eighty-three feet. There are, at present, but two stopes worked, although a new one is in progress. These worked, are designated as the middle and bottom. The middle stope is seven hundred and thirty feet from the plane, measuring on the gallery leading to it; the bottom stope is two hundred and ten feet from the foot of the plane, measuring in the same way. The deepest working in the mine, which is now the sink, is one hundred and seventy-five feet below the surface. There are two shafts, at present, open at the surface, one of which, the pump, *a*, measures eighty-five feet in depth. This shaft, as will be seen from the measurement, does not reach to the bottom of the mine; and the water is raised at successive lifts from one gallery to another. The other, called the chain way, or grass shaft *h*, is sunk one hundred and eighty-eight feet below the surface.

The thickness of the deposit at the northeast stope is nine feet but is here mixed with seams of rock; at the middle stope, the ore measures thirteen feet, and at the bottom stope, ten. Towards the southwest, it becomes narrower; and in the sink it is but three feet. At different places, along the plane, the thickness measures three and a half, two, and two and a half feet. The thickness in the gallery, at the southwest end, back of the plane, is one, and one and a half feet. The average dip is 57 deg. N. W.

The following are extracts from Mr. Wurtz's report:

"This large mine, important both on account of its convenient proximity to the canal and the very large quantity and valuable quality of ore which has been, and still is, taken out of it, is worked upon an extensive but irregular bed of ore, or rather of a mixture of ore and black hornblende, which has the usual stratum-like form and correspondence with the beds of the surrounding crystalline schists in its N. E. and S. W. strike and steep dip to the S. E. The 'vein,' so called by the miners, is made up of a series of subordinate beds or seams, mostly composed as above stated, of mixtures in variable proportions, of magnetic iron and black hornblende in crystals of considerable size, some seams however being composed of magnetic iron, more or less pure, and some of feldspar or quartz. Neither pyrites nor phosphate of lime were observed to be present in the ore at any time.

"The specimens were collected from three parts of the mine, from the N. E. and S. W. extremities of the present workings, and from a point intermediate between them, called the middle stopes. These three points are at different elevations, the N. E. stopes being nearest the surface of the ground, the S. W. stopes the deepest part of the mine, and the middle stopes intermediate between them. A great portion of the mine lying still farther to the S. W., from which the ore has been wholly or partially worked out, is inaccessible, in consequence of the columns of ore left to support the hanging wall, at the time it was worked, having been removed, and the earth from above allowed to fall in, and fill up the excavation.

"(1.) At the N. E. stopes the hanging wall is a feldspathic schist, containing a little quartz and some laminæ of black hornblende and magnetic iron.

"The ore taken from the central portions of the bed is a coarsely granular mixture of black hornblende and magnetic

iron in variable proportions. An imperfectly developed schistose structure appeared in some places. It has no jointed structure.

"The foot-wall is very similar in appearance to the ore, but has a quite distinct schistose structure, and contains more hornblende, together with considerable feldspar. It seems probable, however, that at this place the true foot-wall had not been reached, and that this was one of the poorer seams of the ore bed, lying in proximity to the foot-wall.

"(2.) At the middle stopes the hanging wall is a mixture of crystals of considerable size of black hornblende, feldspar and magnetic iron, having a doubtful schistose structure.

"The ore is precisely similar to that at the N. E. stopes, with sometimes a few joints. It is also indistinctly schistose in places.

"The foot-wall is an indistinctly schistose, small granular, crystalline, feldspathic rock, with a little quartz and a few minute grains of magnetite interspersed. It contains also some pyrites.

"(3.) At the S. W. stopes, the hanging wall is a mixture of large crystals of flesh-colored feldspar and quartz, with a few grains of magnetic iron interspersed. It has a schistose structure, sometimes however imperfectly developed.

"The ore is large granular and crystalline; sometimes schistose, some laminæ consisting of altered hornblende; and sometimes very pure, with a jointed structure. It is somewhat stained with limonite.

"The foot-wall is a small granular feldspathic rock, containing intermixed grains of magnetic iron, and sometimes seams of the same mixed with hornblende. It has in most places no visible schistose structure.

"(4.) Specimens were also taken of a 'horse' found in the ore, which is a crystalline feldspathic rock, apparently destitute

of schistose structure, containing, in some places, some diffused brown mica, and in others diffused particles of magnetic iron.

"(5.) The miscellaneous specimens comprise masses of feldspar presenting cleavage surfaces an inch in diameter, which belong to the species orthoclase, according to measurement of the angle between the cleavages; seams of magnetic iron in feldspathic gneiss, showing the junction of the ore and rock; a schist of a peculiar and beautiful appearance, composed of a mixture of brown or black mica with a white altered feldspar, the plates of mica being oblong and arranged in a parallel manner; seams of feldspar composed of large crystals in hornblendic gneiss; incrustations of dog-tooth spar in seams in the ore. There were also several specimens which time has not yet permitted me to examine, such as some crystals apparently of a zeolitic mineral; a blue or violet colored substance in amorphous incrustations, etc. A specimen was also found containing many minute crystals of zircon."

MINING.

Having described the geological occurrence of the principal deposits of iron ore, in this part of the metalliferous belt of the Highlands, a few general remarks on the principles of a proper system of mining, as applied to these and similar metalliferous deposits, are deemed of essential importance, in connection with their development.

On account of the great abundance and accessibility of the ore, that attention has not been paid to a systematic and economic plan of extraction which the nature of the art demands.

The manner in which the iron ore of this district has been hitherto chiefly extracted from its bed is as follows: A deposit of ore having been discovered in the summit of a hill or mountain ridge, operations are commenced at its outcrop, either removing it for a distance on the surface, or sinking into it, until the work becomes too expensive on account of the water

which accumulates, or on account of the deficiency of machinery for raising the ore and removing the water. Even when machinery is erected, it is often imperfectly adapted to the work, and thus renders the expense of the work too great to be continued. There is also but little attention paid to the proper construction of mines, regard being had only to the extraction of the ore at the time, and no provision being made for extensions which may hereafter become necessary. This frequently results, sooner or later, in unprofitable and dangerous workings.

Exploring for Ore.—A gradual increase in the manufacture of iron from its ore, in this country, has of late led to the exploration of the iron region of this State in search of that material. A knowledge of the geographical range of its belts, together with their geological position and character, as delineated in the preceding pages, will serve to guide the explorer in his researches for undiscovered deposits, and also for adopting plans by which they may be worked to the best advantage.

The following facts, having a practical bearing on their discovery and working, have been determined:

1st. Geographically, the deposits of ore occur in a series of parallel belts crossing the Highlands, in a northeasterly and southwesterly direction.

2d. Each belt is composed of a series of deposits having the same general direction and inclination, coinciding with the strike and dip of its accompanying rocks.

3d. As a general rule each deposit is exposed at the surface only to a very limited extent, on account of its pitch beneath the rocks, towards the northeast.

4th. The outcrop of ore generally occurs on, or near, the summit of a hill or mountain ridge.

5th. The deposits are traversed by numerous joints and faults, frequently displacing portions of them to a considerable distance.

From these facts it will be observed that the explorer would

be more likely to succeed in his researches for ore, if he should come within the range of a metalliferous belt, although this is not to be considered as an established rule, for deposits sometimes occur at a considerable distance from the conceded limits of a belt. Examinations should be made on, or near, the summit of hills and ridges, also at their base; the former would lead to the discovery of the outcrop, while the character of a loose piece of rock, and sometimes ore, found along the base of the ridge, would indicate that it had been detached from its bed on the summit, or side, and rolled down its slope. As in many cases the wall rocks of a deposit of ore possess the same general character for a considerable distance, a knowledge of them will assist in locating a deposit which may be capped with rock.

On account of the highly magnetic property of the ore, the magnetic needle, or surveyor's compass, is an instrument very generally used in exploring for it; and although it indicates the presence of magnetic iron ore, yet it cannot be relied on as to the quantity and extent of the deposit. This is due to the almost universal occurrence of magnetic iron ore either in grains, seams, bands, etc., as a constituent of the gneissoid and granitic rocks of this region.

A great variety of needles, or compasses, has been manufactured as best adapted to this purpose, depending chiefly on the manner in which the needle is mounted. It is, however, conceded by those who are experienced in the use of these instruments, that the common pocket box compass is as well adapted and reliable as the more complicated and costly instruments made expressly for this purpose.

The ordinary way of using the pocket compass in exploring for ore, is as follows: the explorer, holding it in his hand, near the ground, taking care to keep it level that the needle may swing freely, crosses the locality under examination in a northwesterly or southeasterly direction, at right angles to the general direction of the deposit, at the same time closely watching the

movements of the needle. If magnetic iron ore be present, the magnetic pole of the deposit (the deposits generally possessing magnetic polarity) which is nearest, will begin to attract the opposite pole of the needle, and this attraction will continue to grow stronger until a position is reached directly over it. The needle will then settle firmly in the direction of the longer axis of the ore deposit, and if the attraction be strong it will not move from that position even though the compass be shaken. Sometimes, as the ore lies in parallel beds, two or three successive attractions will be observed, the needle at each time behaving in a similar manner. A very good illustration of the attraction and repulsion of different poles of the magnet may sometimes be obtained by walking upon, and in the direction of the ore deposit. When a certain point is reached, the needle will be reversed. There are two places on the deposit at the Richard Mine where this is exhibited.

The indications of the compass are often very deceptive; for the needle may stand very firmly where there is but a small mass of ore, if it be near the surface; and, on the other hand, if it be some distance below the surface, the needle may give but a very faint indication, when in reality there is a large body of ore.

Having located a deposit of ore, its probable extent and quality should be determined before making arrangements for working it on a large scale. This is necessary on account of the frequent occurrence of bands, bunches, and seams of ore, which do not expand to any considerable size. The manner of determining its probable quantity depends on the nature of the locality, extent of the outcrop, etc. This is generally done by sinking small test or trial shafts, cross-cuts, borings, etc. Having determined by these examinations that the extent of the deposit and quality of the ore are of a character to warrant the opening of the mine, and extending the workings to an indefinite extent, a survey of the premises, showing the irregularities of the surface, the position

of the deposit both as regards its strike, dip, etc., should be made and plotted on paper, before a hammer or pick is used. Such a survey will enable the experienced mining engineer to determine the most feasible plan for conducting his operations, a matter of the greatest importance in working iron mines in this region, where the value of ore, in proportion to its bulk, is very small.

Open Workings.—The simplest method of mining is by what are called "open workings;" but this is only applicable where the mineral is in large quantity and near the surface. The plan usually followed in this case is first to strip off all the earth, or other superincumbent material, and then to conduct the workings in regular terraces, so as to facilitate the removal of the ore and rubbish with the least possible expense. The crumbling or washing down of the sides must be guarded against, by giving them a proper slope or by props of timber; and ditches, or water drains and surface drains, must be dug, in order to keep the workings dry, as far as possible, in wet and stormy weather, and during the winter season. The mine that has been worked most extensively on this principle is that at Andover, Sussex Co.

Underground Workings.—The other method, and that which in most cases has to be resorted to, is by underground or subterraneous workings. These are commenced and continued, either by shafts, or levels, or both, as the nature of the ground and the position of the deposit may demand.

In all cases where the configuration of the surface, and the situation of the mineral deposit will allow, an "adit-level" should be driven either in the deposit or from the lowest ground adjoining. When the deposit crosses the general direction of the ridge, or hill, in which it is situated, the adit should be driven into it upon its course. The Wood Mine at Hibernia, is a good illustration of this kind of adit. But when the deposit runs along the side of a ridge or hill, parallel to its course, the adit must be cut through the adjacent rocks, which is frequently

a very expensive undertaking. In the case of a "shaft," which is the other alternative, the cost of machinery, of pumps, repairs and attendance, are to be considered. When the nature of the surface will not allow an adit-level, a shaft must be sunk, its location being determined from the position of the deposit, its dip, etc. When a deposit of ore has been removed above the adit-level, the working is continued by means of shafts, through which the ore may be raised, and the water pumped to the level.

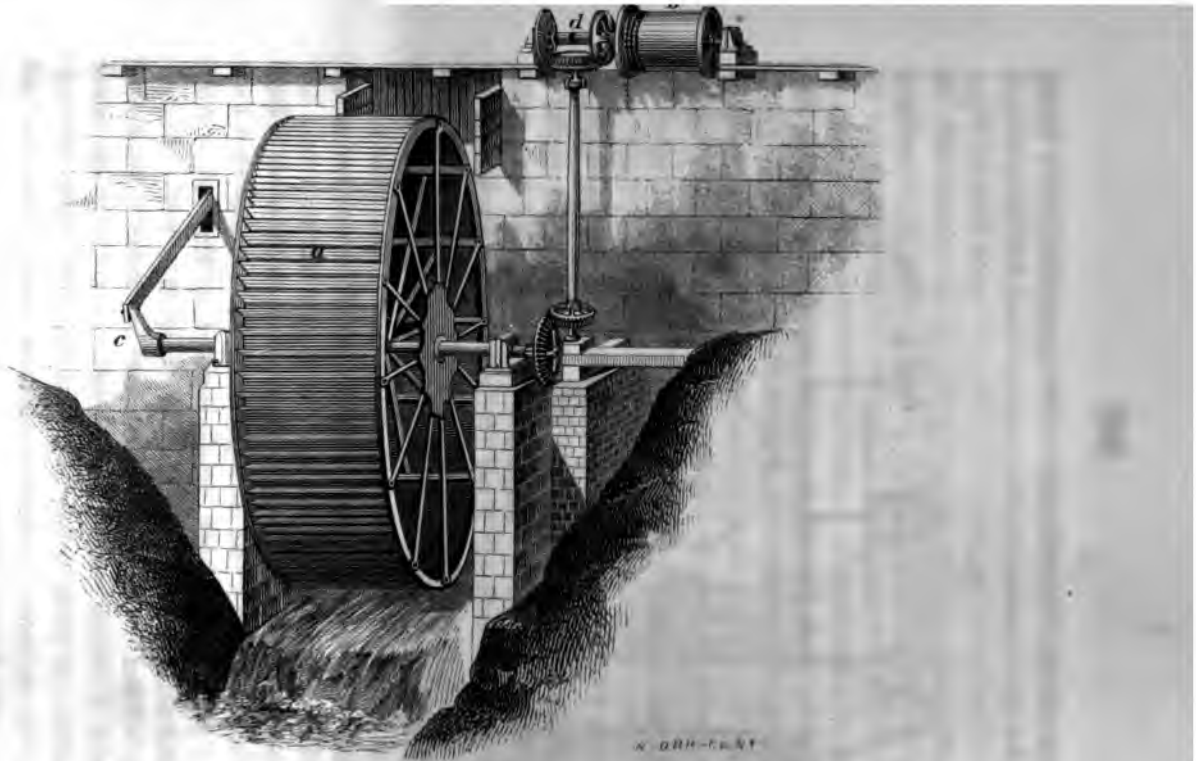
Timbering.—In all shafts or levels which are sunk or driven through earth or loose rock, the practice of "timbering" must be resorted to, in order to prevent these substances from falling into, and filling up the excavation. The wood most generally used for this purpose, in the New Jersey iron mines, is chestnut; though locust, white oak, red oak, red pine, or any other durable wood, will answer the purpose. It should be flattened on two sides, stripped of the bark and seasoned, before it is put into the mine. Its size should not, as a general rule, exceed ten inches in thickness, on account of inconvenience in handling, as machinery or pulleys cannot well be used in a mine, and the sticks must consequently be set by hand.

The timbering of a shaft is usually rectangular in form; and in most mines requires only to be carried through the loose earth and disintegrated portions of the rock above, or until solid rock is reached, which is usually not over thirty feet; here it rests on a bed cut in the rock, sufficiently solid to prevent its displacement. The timbering in an adit is different from that in a shaft, being somewhat smaller at the top than at the bottom on account of inclining side posts, in order to resist the pressure. It should usually be six or seven feet high, five or six feet wide at the bottom, and three at the top. The timbering in the galleries and other parts of the mine consists merely of heavy timbers extending from wall to wall, one end being set into a step cut into the foot-wall to receive, and the other bearing against the hanging wall. If the wall be slaty or unsound, the timber may bear

against a wall-plate of plank, in order that it may give support to a large surface.

Extraction of Ore.—After the shafts have been sunk and galleries run horizontally from them, the work of extracting ore begins. This is done by what is called "stoping," or working in steps. There are two methods of doing this, one called overhand, and the other underhand stoping. The difference between them is, that in the former the ore is removed from below upwards; while in the other method it is removed from above downwards. The latter method is usually adopted in this region, and is considered the most economical. A good illustration is given in the section of Sweed's Mine, (Fig. 12, page 230), showing three stopes. The lean ore and rubbish is piled upon the timbers put in to support the walls, thus forming what are termed "stulls." In these piles of rubbish, openings called "mills, passes or shoots," are left, through which the ore may be thrown down into a car on the level or gallery below. The rubbish piled upon the timbers forms an additional support to the walls in those parts from which the ore has been removed. It is a great fault in most of these iron mines that too much stoping surface is exposed. The reason of this is, that the deposits, in most instances, are so wide and so pure that they are removed without leaving any rubbish to support the walls. The mines are thus so open as to be very dangerous for the workmen. When there is not enough rubbish furnished by the mine it may be obtained, when the underhand method is pursued, by cutting away the timbers and letting down that from above; and when enough is not furnished by this expedient, it may be thrown down from the surface. This method is advantageously pursued at Sweed's Mine.

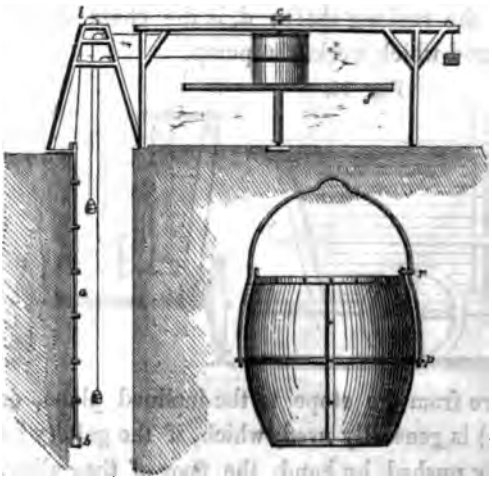
Hauling and Hoisting.—In beginning to sink a shaft, for the first fifty or sixty feet, the ore, rock and rubbish, may be raised by means of a common windlass, such as that used in wells. When the shaft does not exceed one hundred and fifty



MACHINERY, SWEEDS MINE.

feet in depth, the work may be done economically by a horse; and the machine used for this purpose is called a horse-whim, a good form of which is represented in Fig. 13. Sometimes an arrangement for pumping is connected with it, as seen in the same figure. The horse, by turning the sweep *f*, winds the chain upon the drum, and thus raises the "kibble," which is made to descend by reversing the motion of the sweep. If, however, the shaft exceeds one hundred and fifty feet in depth, water or steam power may be more advantageously employed, though either of these may be economically used at the very beginning, provided operations are carried on to a great extent.

Fig. 13.



HORSE-WHIM AND PUMP.

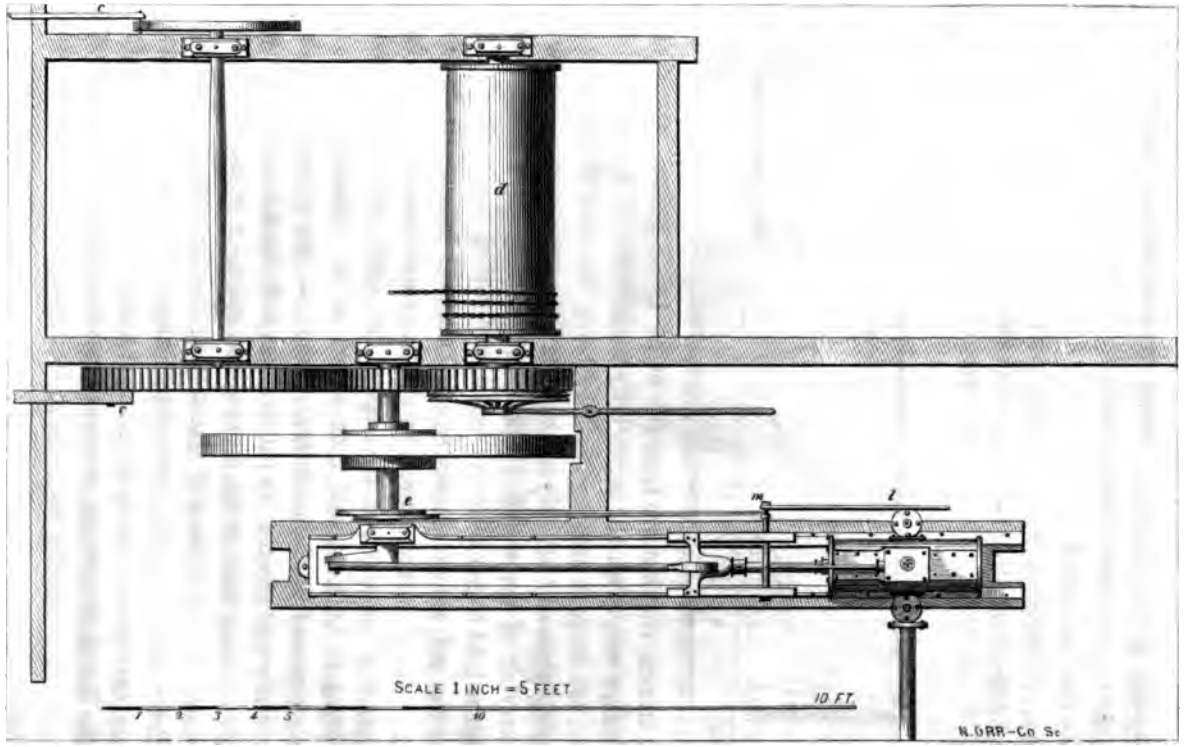
In Sweed's and Mount Pleasant mines, the hoisting is done by water power. The arrangement of the machinery used for this purpose at Sweed's Mine, is shown in Fig. 14; *a* is the water wheel, connected by means of mitre gearing with the chain drum. The motion is reversed by means of the sliding clutch *d*, which connects the drum with either of the mitre wheels *e* or *f*, as a forward or backward motion is required. The motive power, by this arrangement, may be always in one direction, as is necessarily the case when water is used.

In the use of steam power various kinds of engines are employed. Those at the Glendon and Byram mines, (see Fig. 15) are very convenient in form for small workings, being simple in their con-

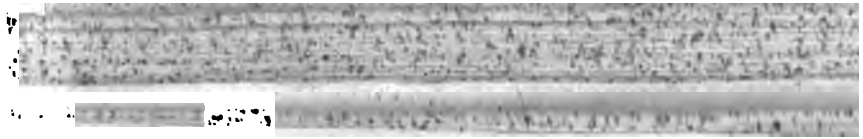
struction and arrangement. They are provided with two eccentrics, *e e*, by which the motion may be reversed. The valve may also be worked by hand, for a short time, by means of the lever, *l*, attached to the rocking shaft; *d*, is the chain drum; and *c* the connecting rod which works the pump.

Fig. 16.

In removing the ore from the stope to the inclined plane, or shaft, a car, (Fig. 16) is generally used, which, if the gallery be not too long, is easily pushed by hand, the floor of the gallery being generally slightly inclined for this purpose, as well as for carrying off the water. The cars generally used at the iron mines hold from one to one and a half tons of ore. They have, at one end, a door, through which the load is discharged. Where the mine is worked entirely by shafts, cars are sometimes used for bringing the ore from the stope to the shaft, where it is transferred to buckets, and then raised to the surface. But this plan causes much unnecessary labor, as the object might be equally well effected by running the cars upon a platform, and then raising them to the surface—an operation which would dispense with the labor of transferring the ore from the cars into the "kibble." The same object might be effected by running the cars themselves up an inclined plane to the surface. When the dip of the deposit does not exceed 40 or 50 deg., the plane may be on its foot wall, as at the Byram, Sterling and other mines, or it may be in the direction of the deposit, as seen in the section of the Sweed's Mine, the arrangements for the work-

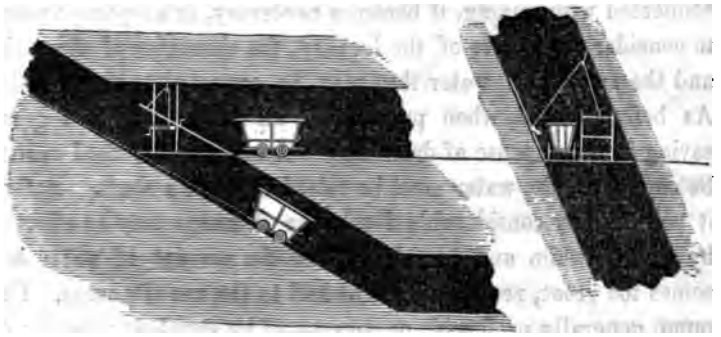


Engine, with Machinery for Hoisting and Pumping, Byram Mine.



ing of which are, perhaps as economical as any adopted throughout the Highlands. There are two adits to this mine, perpendicular to the direction of the deposit, and entering the hill at *a* and *b*. The ore here is loaded into the cars at the stopes, and then pushed by hand to the plane *c*, where a chain is attached to them, by which they are raised as far as the gallery *e*. Then they are drawn by a mule through the adit *a*, to the canal bank, and emptied directly into the boat.

Fig. 17.



A very ingenious arrangement, used for connecting the galleries with the plane, is shown at Fig. 17. When the car is to pass to the lower gallery, the track of the upper gallery is raised by the windlass and block, and the car passes under; but if it is to go on the upper gallery, the track is let down into its places and the car runs into it.

The pumping arrangement at this mine is also very simple and convenient. The water is raised at three successive lifts, from one gallery to another, and discharged at the adit *a*, (see Fig. 12, page 230,) whence it runs into the canal. At the mouth of the adit, there is a trough arranged for washing ore with the water from the mine. The pumps used are of the common "lifting" kind, and are nine inches in diameter.

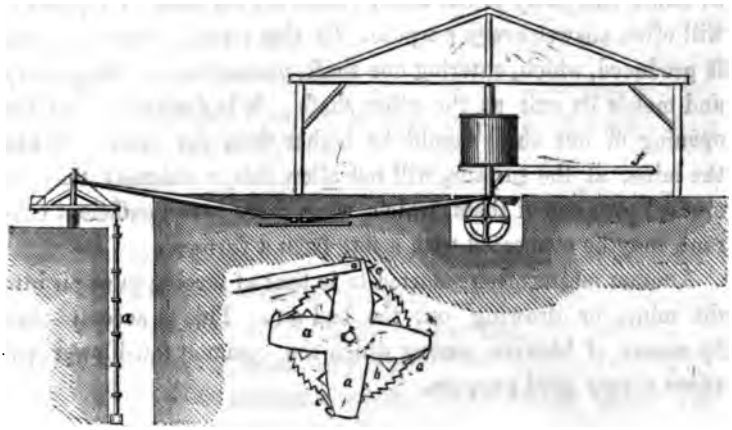
In the section is shown the manner in which a new stope is begun. The shaft *f*, is first sunk to a depth equal to the required height of the stope, a pump being carried down with it to prevent the water from interfering with the workmen. The angle is then worked off in the manner indicated by the dotted line; and a new stope is thus formed, and a new gallery begun. A similar method of beginning a stope is shown in the section of the Byram Mine.

DRAINAGE.—As this is one of the most expensive operations connected with mining, it becomes necessary, in adopting a plan, to consider the nature of the locality, the character of the rock, and the amount of water that may be expected to accumulate. As before stated, when practicable, an adit will effect a great saving in the expense of draining; but when this method cannot be employed, the water must be raised through a shaft. Before it reaches any considerable depth the drainage may be effected by a horse-whim and barrel. When the amount of water becomes too great, recourse must be had to the use of pumps. The pump generally preferred, on account of its simplicity, facility of repair, etc., is the "lifting pump," or combination of the "sucking" and "lifting pump," inasmuch as it raises the water by "suction" for the first twenty-five feet, and lifts it through the remaining distance. This pump is not easily deranged, and if it should become so, is readily repaired when under water.

Pumping, as well as hoisting, may, in the beginning, be effected by horse power, the pump being connected with the whim, as shown in Fig. 13, page 241. *a* is the pump, worked by a chain which, passing over the pulley, is connected to the crank at *c*. The weight *w* is a counterpoise for the purpose of moderating the force of the "back-lash," caused by the weight of the pump-rod and the column of water raised at each stroke. Another arrangement, in use at the Richards Mine, by which the back-lash

is avoided, is shown in Fig. 18, the connection for working the

Fig. 18.



pump being below instead of above, as in the preceding figure. In this arrangement the connecting-rod is attached to a pair of iron cross-arms *a a*, which, in one direction, may revolve independent of the ratchet-wheel, with which they are connected in the other direction by the spring-catches *c c c*. When the rod begins the downward movement, its weight, with that of the water above the bucket, causes it to descend with great force, and thus the arms are made to revolve with greater rapidity than the ratchet, though in the same direction. When the rod has fallen as far as its weight will carry it, the arms are again taken hold of by the ratchet, and carried forward as before. In this way, by the falling forward of the rod, nearly a quarter of a revolution is gained each time. By using a pump connected in this manner with the hoisting arrangements, the mine is freed from water at the same time that the ore is hoisted. The engine best adapted to pumping is the modification of the Boulton and Watt engine, now generally known as the Cornish engine.

Ventilation.—The air of mines becoming vitiated by the breathing of the miners, the burning of candles and lamps, and

the explosion of gunpowder, recourse must be had to some means for purifying it. This may be effected in various ways. A shaft at either extremity of the mine, connected together by a gallery, will often answer every purpose. By this means a current of air is produced, which, entering one shaft, passes through the gallery and makes its exit at the other shaft. It is desirable that the opening of one shaft should be higher than the other. When the mine, at the surface, will not allow this, a chimney may be erected over one of them, which, when there is not sufficient current, may be connected with a flue from a furnace.

Another means often resorted to is that of forcing pure air into the mine, or drawing out the bad air. This is accomplished by means of blowers, among which the common fan-blower answers a very good purpose.

CONCLUSION.

As soon as the explorations shall have been completed over the whole of the metalliferous belt of the Highlands, generalizations will be made, that will show in a condensed and tabular form:

1st. The different varieties and character of its ores.

2d. Their chemical composition, and their relative economic value.

3d. Their geological position, and their geographical distribution.

4th. Their natural advantages for being extracted.

5th. The manner in which they should be mixed; the fluxes and fuel that should be used, as best adapted to the manufacturing of different kinds of iron.

6th. The most favorable locations for the erection of iron works, combining the greatest advantages as derived from the above considerations.

Enough, however, has been said in the detailed descriptions of the principal mines, as contained in the preceding pages of this report, to show that this district is pre-eminently an iron-ore-

bearing district, unrivalled by any like extent of territory in the Union. With very great propriety, indeed, did an eminent statesman recently propose that New Jersey be called "*The Iron State;*" for it may be said, with entire truth, that the mountain deposits of iron-ore, above water-level, in its Highlands, are sufficient to supply the demand for iron in the United States for many years to come.

The following considerations determine the most advantageous location for the manufacturing of iron:

1st. Quality, quantity, and accessibility of the ore.

2d. Cost and nature of the fuel to be employed.

3d. Cost and accessibility of the proper fluxes.

4th. Cost of labor, machinery, etc.

5th. Proximity to market.

Does not this district, possessing the richest of ores, in its mountain deposits, of magnetic, specular, hematite, franklinite, and bog ores, the best of fluxes in its great variety of limestones, its accessibility to the anthracite coal-fields of Pennsylvania, its proximity to New York and Philadelphia, the great iron depots of the country, combine all these advantages in a remarkable degree? There is no reason, then, why New Jersey shoud not become, *par excellence*, the greatest iron-producing State in the Union. Statistics show that the annual consumption of iron in the United States, during the past few years, is not far from 1,500,000 tons, of which only about 800,000 tons have been produced here. This consumption is annually increasing by the use of iron in the construction of railroads, iron buildings, vessels, pavements, etc.; and do not these facts demonstrate that the manufacturing of iron must be increased in this country? But where will these manufactories be located? Undoubtedly where the purest and most accessible ore is found in proximity to an abundance of fuel and fluxes, as well as to a proper market.

The increasing intelligence and enterprise of the citizens of this State, are rapidly leading to the development of the natural

resources of its territory; and it is reasonable to believe that the day is not distant when the numerous forges situated upon its mountain streams, converted into extensive iron works, will, in a great measure, supply the increasing demand for this indispensable metal.

The development of the mineral resources of the Highlands of New Jersey, is a subject not merely of State interest, but of great national importance; and every step which the State takes towards proclaiming to the world the extent, character, and situation of these resources, will increase ten-fold the value of its territory. It has already been demonstrated, with respect to its Highlands, that the salubrity of its climate, the beauty of its scenery, its undeveloped resources, its unoccupied water power, and its facilities for internal communication, offer inducements for the safe investment of capital, that will amply reward honest industry and persevering enterprise.

WILLIAM KITCHELL,
Superintendent and State Geologist.

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THIRD ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF NEW JERSEY,

FOR THE YEAR 1856.

TRENTON:
PRINTED AT THE "TRUE AMERICAN" OFFICE.
1857.

the explosion of gunpowder, recourse must be had to some means for purifying it. This may be effected in various ways. A shaft at either extremity of the mine, connected together by a gallery, will often answer every purpose. By this means a current of air is produced, which, entering one shaft, passes through the gallery and makes its exit at the other shaft. It is desirable that the opening of one shaft should be higher than the other. When the mine, at the surface, will not allow this, a chimney may be erected over one of them, which, when there is not sufficient current, may be connected with a flue from a furnace.

Another means often resorted to is that of forcing pure air into the mine, or drawing out the bad air. This is accomplished by means of blowers, among which the common fan-blower answers a very good purpose.

CONCLUSION.

As soon as the explorations shall have been completed over the whole of the metalliferous belt of the Highlands, generalizations will be made, that will show in a condensed and tabular form:

1st. The different varieties and character of its ores.

2d. Their chemical composition, and their relative economic value.

3d. Their geological position, and their geographical distribution.

4th. Their natural advantages for being extracted.

5th. The manner in which they should be mixed; the fluxes and fuel that should be used, as best adapted to the manufacturing of different kinds of iron.

6th. The most favorable locations for the erection of iron works, combining the greatest advantages as derived from the above considerations.

Enough, however, has been said in the detailed descriptions of the principal mines, as contained in the preceding pages of this report, to show that this district is pre-eminently an iron-ore-

bearing district, unrivalled by any like extent of territory in the Union. With very great propriety, indeed, did an eminent statesman recently propose that New Jersey be called "*The Iron State;*" for it may be said, with entire truth, that the mountain deposits of iron-ore, above water-level, in its Highlands, are sufficient to supply the demand for iron in the United States for many years to come.

The following considerations determine the most advantageous location for the manufacturing of iron:

1st. Quality, quantity, and accessibility of the ore.

2d. Cost and nature of the fuel to be employed.

3d. Cost and accessibility of the proper fluxes.

4th. Cost of labor, machinery, etc.

5th. Proximity to market.

Does not this district, possessing the richest of ores, in its mountain deposits, of magnetic, specular, hematite, franklinite, and bog ores, the best of fluxes in its great variety of limestones, its accessibility to the anthracite coal-fields of Pennsylvania, its proximity to New York and Philadelphia, the great iron depots of the country, combine all these advantages in a remarkable degree? There is no reason, then, why New Jersey shoud not become, *par excellence*, the greatest iron-producing State in the Union. Statistics show that the annual consumption of iron in the United States, during the past few years, is not far from 1,500,000 tons, of which only about 800,000 tons have been produced here. This consumption is annually increasing by the use of iron in the construction of railroads, iron buildings, vessels, pavements, etc.; and do not these facts demonstrate that the manufacturing of iron must be increased in this country? But where will these manufactories be located? Undoubtedly where the purest and most accessible ore is found in proximity to an abundance of fuel and fluxes, as well as to a proper market.

The increasing intelligence and enterprise of the citizens of this State, are rapidly leading to the development of the natural

resources of its territory; and it is reasonable to believe that the day is not distant when the numerous forges situated upon its mountain streams, converted into extensive iron works, will, in a great measure, supply the increasing demand for this indispensable metal.

The development of the mineral resources of the Highlands of New Jersey, is a subject not merely of State interest, but of great national importance; and every step which the State takes towards proclaiming to the world the extent, character, and situation of these resources, will increase ten-fold the value of its territory. It has already been demonstrated, with respect to its Highlands, that the salubrity of its climate, the beauty of its scenery, its undeveloped resources, its unoccupied water power, and its facilities for internal communication, offer inducements for the safe investment of capital, that will amply reward honest industry and persevering enterprise.

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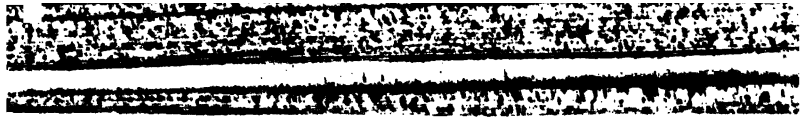


To His Excellency,

RODMAN M. PRICE,

Governor of New Jersey:

Sir:

I have the honor herewith to submit to you the Third Annual Report on the Progress of the State Geological Survey, for the year 1856.

Very respectfully, your obedient servant,

WILLIAM KITCHELL,

Superintendent of N. J. State Geological Survey.

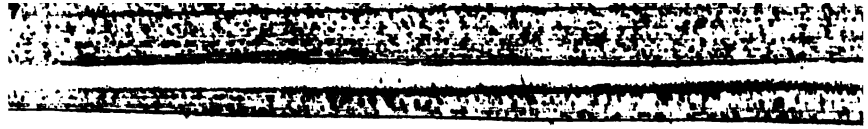
Newark, N. J., January 2d, 1857.

REPORT

OF THE

SUPERINTENDENT AND STATE GEOLOGIST,

FOR THE YEAR 1856.



REPORT.

At the commencement of the past year, the survey was in a condition to be actively prosecuted. The parties that had been previously organised and engaged in the field, had become sufficiently well acquainted with the nature of the researches required, to secure a rapid advancement of the work. Reconnoisances had been made, the preliminary arrangements attendant upon a work of this kind and extent were completed, and a large quantity of material had been collected and was in a condition to be systematized and employed in the preparation of the final County Reports.

Under these favorable circumstances, an appropriation of twenty-five thousand dollars was asked, for the purpose of advancing the survey, in accordance with the law, in the most expeditious and economic manner.

The appropriation having been made, the work in the office and laboratory was continued. The parties were prepared to enter the field as early as the season would allow.

Such was the condition of the survey when I received your instructions to close up its business, as it would be necessary to suspend operations on the first of May—the State Treasury not being in a condition to provide for the appropriation.

It was a matter of deep regret to myself, as well as to those who, appreciating the importance of this work, had labored to sustain it thus far, hoping to see it completed at an early day, in accordance with the plan that had been adopted.

It was evident that merely a temporary suspension of the

survey would be a great loss to the State, inasmuch as the parties which had been organised with considerable difficulty, and had just become acquainted with the nature of their work, must be discharged, and researches but partially completed must be abandoned, and the various materials collected laid aside in a confused and disarranged state.

With a view, therefore, to preventing this, we were led to proffer the continuation of our services in the prosecution of the survey, believing that the next legislature would provide for the appropriation made at the last session.

Under these contingencies, the survey has been prosecuted during the past year, and although there has not been as much accomplished as was anticipated at the commencement of the year, nevertheless the work has actively progressed, and an additional stock of material has been collected, together with that which has been arranged for the preparation of the Final Reports.

TOPOGRAPHICAL DEPARTMENT.

This department of the survey has been prosecuted under the direction of Mr. E. L. Viele. A reference to his report will show the progress made.

CHEMICAL DEPARTMENT.

After the active operations of the survey were temporarily suspended on the first of May, Mr. Wurtz did not resume this department, consequently the series of quantitative analyses that he had commenced were not completed.

Mr. Kock, who had been previously engaged in Professor Cook's laboratory, has continued his services during the year, in researches connected with the geological department of the Southern Division of the State.

Dr. Ritschel has been engaged in my laboratory, in Newark, in the analysis of the iron ores and limestones of Sussex and Morris counties, and of the rocks of Essex and Hudson counties. In all, forty quantitative analyses have been

completed, which will be reserved for the Final County Reports.

PALÆONTOLOGICAL DEPARTMENT.

Owing to the illness of Professor Hall, no progress has been made in this department, except in the collection of specimens, of which large additions have been made to the stock already on hand. Some of them have been sent to Professor Hall, at Albany, and they will be described and arranged as early as possible.

GEOLOGICAL DEPARTMENT.

In the Southern Division of the State, this department has been actively prosecuted, as a reference to the annexed report of Professor Cook will show. The Final Report on the County of Cape May has been prepared, and is now in the hands of the printer. It will be printed and ready for delivery, per contract, on the eighth instant. Researches have been made in other counties, of which the field work of Monmouth is nearly completed.

In the Northern Division, I have been personally engaged. Messrs. E. Haeusser and E. F. Baldwin have assisted me during a part of the year; the former in the counties of Sussex and Morris—the latter in the counties of Essex and Hudson.

In Sussex County, the different geological formations have been traced out and are located; sections showing their relative position and elevation have been made, and many of the minerals have been described. The metalliferous deposits have been examined and described, and a great part of the final report has been prepared. The whole county is in a condition to be reported on finally, as soon as the map is engraved and characteristic fossils of its formations described.

In Morris County, nearly the whole of the field work has been completed—at least as much as could be done until the map, which is nearly finished, shall have been placed in my

hands. The formations have been examined, sections made, analyses of the iron ores, limestones, and serpentines completed, fossils collected, &c., &c., &c.

In Essex County, a detailed examination of the townships of Belleville, Bloomfield, Orange, Newark, Clinton, and Union has been made.

A detailed examination of the elevated portions of Hudson County, together with a more general one of the salt marshes along the Hackensack and Passaic Rivers, has also been made. The field-work of this county can be completed in two weeks, and the final report thereon prepared as soon as the map is finished.

In my last annual report, upwards of eighty iron mines were enumerated and described, all of which are situated in the counties of Sussex, Passaic, Morris, and Warren, and within an area of three hundred and sixty square miles.

Although some of them have been worked for a century and a half, and in early days furnished a very large proportion of the ore manufactured into iron in this country, yet they have been excavated to a very limited extent, many of them containing immense bodies of ore above water-level which may be economically extracted without the employment of expensive machinery.

It is estimated that they could be made to yield, advantageously, no less than one million tons of ore annually for many years to come, which would be sufficient to supply half of the present annual consumption of iron in the United States.

With a view to demonstrating the general character of these ores, together with their great economic importance, they will be considered briefly in this report, under the two following heads:

I. Geological occurrence and properties of the magnetic iron ores.

II. Metallurgy of the iron ores.

I.—GEOLOGICAL OCCURRENCE AND PROPERTIES OF THE IRON ORES.

The different forms in which magnetic iron ore occurs in this district, are as follows:

First, in granules disseminated through the gneissoid rock as one of its necessary constituent minerals. The granules vary in size from particles so small that they cannot be seen with the naked eye, to grains corresponding in size with the other constituent minerals of the rock.

Second, in masses or bunches of very limited extent. This form generally occurs in those rocks that are the most highly metamorphosed—as the quartzo-feldspathic and syenitic rocks. These rocks, when considered with respect to their constituent minerals, do not exhibit a distinct lamination, nor when considered *en masse* do they exhibit distinct lines of stratification, as in gneiss or in mica and hornblendic schists; nevertheless, they generally pass into these latter rocks so insensibly that no line of demarcation can be drawn between them.

Third, in seams or strata, varying from the fraction of an inch to thirty feet in thickness. They alternate with strata of rock and coincide with them in strike and dip.

The ore seams, as well as the rocky strata, pitch downward beneath the surface towards the northeast at variable angles, and on this account the ore is exposed on the surface but to a very limited extent.

The seams or deposits of ore are generally remarkably pure, but they frequently contain in admixture the constituent minerals of their accompanying rocks. Apatite (phosphate of lime), hornblende, quartz, feldspar, and mica, are most common. In some portions, as in the Dickerson and Byram ores, apatite, in the form of granules, uniformly disseminated through the ore seam, constitutes as much as ten per cent. of it. This per centage may be considered as the maximum, and confined to few mines, and even to very limited spaces in those mines.

Hornblende frequently enters largely into its composition,

as in the Sweeds mine, and many others. Mica, feldspar and hornblende are very frequently found entering largely into the composition of the ore seam, sometimes in granules irregularly disseminated through it, as in the Hibernia mines, and sometimes in laminæ alternating with laminæ of ore, as in the Beachglenn mine. Iron pyrites (sulphuret of iron) is also a common constituent of many of the deposits, among which may be mentioned the Silver, Haggerty and Stanhope mines. Quartz in small proportion, in the form of granules, disseminated throughout the ore, is not uncommon.

Generally, when the ore contains a considerable quantity of the above mentioned minerals in admixture, it is laminated, the planes of the lamination depending on one or more of the minerals. When, however, it is entirely or nearly free from impurities, it possesses a columnar structure, the general direction of the planes of the joints being at right angles to the inclination or dip of the ore seam.

Large wedge-shaped masses of rock, composed of quartz, hornblende, feldspar, mica and magnetite, called by miners "horses," frequently occur imbedded in the ore seams. Generally a line of demarcation can be drawn between the "horse rock" and ore, but so insensibly do they sometimes pass into each other that it is difficult to tell where the one begins and the other ends. They vary in extent, from regular seams or strata of rock alternating with the ore, to small irregular wedge-shaped masses, the longer axis corresponding with the strike of the strata, and its lamination, which is generally perceptible, corresponding with the lamination of the adjoining rocks.

Having described the geological occurrence of magnetic iron ore in this district, we are led to consider its origin, and to refer it to the particular class of metalliferous deposits to which it belongs; whether it is of aqueous or igneous origin; whether it occurs in the form of stratified or unstratified deposits.

That they cannot be referred to the unstratified deposits, appears evident from the facts stated in describing the different forms in which the ore occurs; nevertheless, it has

been maintained by some that they are true veins of igneous origin, which implies that they extend to an indefinite length and breadth, that they differ in character from the rock in which they are situated, and have been formed subsequent to it. Such deposits do not usually coincide with the strike and dip of the strata in which they are enclosed, but generally cross the line of stratification and frequently send off branches of greater or lesser dimension, at different angles from the main vein. The body of the vein is in most cases separated from the walls on either side by decomposed rock called selvage.

It will be observed that none of these phenomena can be applied to the magnetic ore deposits of this district. Nor can they be veins of segregation, which implies that the material of which they are composed has been eliminated or collected together from the surrounding rock by some chemical action. Such deposits are composed of a gangue or materials different from the surrounding rock, and are very irregular in their form.

Stratified deposits imply that they are included within sedimentary rocks, that they are of aqueous origin, and that they coincide in geological position and in the mode of formation with the rocks in which they are situated. From the facts that have already been stated, they must be referred to this class of metalliferous deposits.

That the rocky formation of this district, including the gneiss, the hornblende and mica schists, the magnetic iron ore, and the quartzo-feldspathic rocks, are of metamorphic origin, there can be but little doubt; consequently, it is conceived that they were originally deposited by water in a horizontal position, that they are composed of materials derived from pre-existing rocks, and that they were subsequently disturbed in their position, and altered by metamorphic agencies, which have caused them to assume their present form and position. The origin, therefore, of these deposits of magnetic iron ore, is identical and cotemporaneous with the rocky strata in which they are enclosed.

Whether we consider this ore-bearing district with respect to the deflection of the magnetic needle in different localities on its surface, or with respect to the magnetic polarity of the different seams of ore, or even of hand specimens, it presents a most interesting field for scientific research, which, undoubtedly, would lead to important economic applications.

To such an extent is magnetic iron ore disseminated through the rocky formation, that deflection of the magnetic needle is of frequent occurrence; so much so, that great difficulty is often experienced in surveying with this instrument. The amount of deflection and the distance at which it is produced, depend on the quantity of magnetic ore disseminated in the rock, and its position with respect to the surface; and as these are variable, no rule can be established by which the amount of deflection and the distance at which it is produced can be calculated. A very small mass of magnetic ore near the surface is frequently sufficient to reverse the needle, even when it is placed several feet above the ore, as in the case of a surveyor's compass when supported, on the tripod; and on the other hand, a large body of ore a few feet beneath the surface would produce but a slight deflection.

The ore, whether in seams or small masses, generally possesses magnetic polarity and a magnetic axis. There is, however, a great difference in the amount of influence exerted on the needle in different localities; in some the action being much more powerful and at a greater distance than at others. Seams of ore five feet in thickness, have been observed to deflect the needle at a distance of thirty feet; the intensity of its influence increasing as the magnetic axis of the ore is approached. Some deposits of ore possess more than one magnetic axis. On placing the needle on the out crop of such a deposit, so that the axis of the needle will correspond with the magnetic axis of the ore, and then gradually moving the needle in the direction of the ore

seam, it will be reversed as many times as there are magnetic axes in the deposit. This is probably due to the difference in intensity of the magnetic properties of the ore in different parts of the same deposit. When a seam of ore is capped with rock even to the extent of a few feet, its influence on the magnetic needle when placed directly over it on the surface, is very variable; in some localities producing a great deflection, and in others but very little. So variable have been the results of the observations, with respect to this, that no rule can be established that would determine the greatest depth at which the needle would be affected, nor that would determine the quantity of ore from a given deflection of the needle at the surface.

The smallest fragments of ore frequently possess magnetic polarity and a magnetic axis; the extent of their magnetic qualities depending on their position with respect to the surface; the nearer to the surface, the greater will be their magnetic properties. This appears to depend on the action of surface water and atmospheric agents; for it as been frequently observed that ore when first taken out of a mine at a considerable depth, possessed but slight magnetic properties, but on being exposed to the atmosphere for a few months or years, it would increase so much that excellent hand specimens of loadstone for experimental purposes could be selected therefrom. Seams of ore that contain numerous joints and fissures, through which water and atmospheric agents pass, possess more decided magnetic properties than those which are more compact and less free from crevices and fissures.

Whether the mountain ridges of this district possess magnetic polarity, independent of the deposits of ore therein, I am unable to say, as our observations have not been sufficient to determine.

It is maintained by some that mountain ridges and cones possess magnetic polarity, independent of the presence of magnetic iron ore, while others attribute it invariably to the presence of this mineral, even if it be in quantities so small that they cannot be detected by the naked eye.

survey would be a great loss to the State, inasmuch as the parties which had been organised with considerable difficulty, and had just become acquainted with the nature of their work, must be discharged, and researches but partially completed must be abandoned, and the various materials collected laid aside in a confused and disarranged state.

With a view, therefore, to preventing this, we were led to proffer the continuation of our services in the prosecution of the survey, believing that the next legislature would provide for the appropriation made at the last session.

Under these contingencies, the survey has been prosecuted during the past year, and although there has not been as much accomplished as was anticipated at the commencement of the year, nevertheless the work has actively progressed, and an additional stock of material has been collected, together with that which has been arranged for the preparation of the Final Reports.

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After the active operations of the survey were temporarily suspended on the first of May, Mr. Wurtz did not resume this department, consequently the series of quantitative analyses that he had commenced were not completed.

Mr. Kock, who had been previously engaged in Professor Cook's laboratory, has continued his services during the year, in researches connected with the geological department of the Southern Division of the State.

Dr. Ritschel has been engaged in my laboratory, in Newark, in the analysis of the iron ores and limestones of Sussex and Morris counties, and of the rocks of Essex and Hudson counties. In all, forty quantitative analyses have been

nized mineralogically, and demonstrates the very general distribution of this mineral."

These remarks have a particular application to this district. That the beds or seams of magnetic iron ore produce a much greater effect on the magnetic needle than mountain masses containing only disseminated ore, there can be no doubt. Numerous observations made over this whole district have satisfactorily demonstrated this; for the greater number of the seams of ore in which the mines are situated, have been discovered by indications of the magnetic needle. These facts, therefore, have a very important economic application. The use of the magnetic needle in revealing hidden beds of ore, of sufficient extent to be of economic value, requires considerable experience, together with a knowledge of the magnetic laws, which the different varieties of ore, when considered with respect to their form and extent, possess; even then the indications of the needle are very deceptive.

In order to distinguish between a small body or mass of ore and a continuous seam or large deposit, the distance at which the needle is deflected, together with the extent of the attraction in the direction of the magnetic axis of the ore deposit, should be considered. If it be but a small body of ore, its magnetic force will be confined to a very narrow space; if a continuous seam, it will be proportionably greater.

METALLURGY OF THE ORES.

Of the various forms of apparatus that have been used for the reduction of iron ores in different parts of the world, the three following have been chiefly employed in this State.

1. THE CATALAN FORGE.
2. THE CHARCOAL BLAST FURNACE.
3. THE ANTHRACITE BLAST FURNACE.

To these may be added Renton's Furnace, which was first erected and put into operation in this State.

resources of its territory; and it is reasonable to believe that the day is not distant when the numerous forges situated upon its mountain streams, converted into extensive iron works, will, in a great measure, supply the increasing demand for this indispensable metal.

The development of the mineral resources of the Highlands of New Jersey, is a subject not merely of State interest, but of great national importance; and every step which the State takes towards proclaiming to the world the extent, character, and situation of these resources, will increase ten-fold the value of its territory. It has already been demonstrated, with respect to its Highlands, that the salubrity of its climate, the beauty of its scenery, its undeveloped resources, its unoccupied water power, and its facilities for internal communication, offer inducements for the safe investment of capital, that will amply reward honest industry and persevering enterprise.

WILLIAM KITCHELL,

Superintendent and State Geologist.

two hundred and fifty pounds of ore and twenty-five bushels of coal.

As the process of deoxydizement and reduction progresses, the melted iron collects in the bottom of the fire-place, from whence it is removed in a semi-fluid or pasty mass, and placed upon an anvil, where it is either fashioned into a bloom, or drawn out into bar-iron, by a heavy hammer worked by water-power. When it is made into bar-iron, it requires a succession of heats and hammerings, whereby a larger quantity of materials is consumed in producing a ton of bar-iron; two and a half tons of ore, and five hundred bushels of coal, being the standard quantities allowed.

At many of the forges the iron is manufactured into anchors, which find a ready sale in New York, on account of their superior strength.

RENTON'S FURNACE.

Various attempts have been made from time to time to invent apparatus by which wrought iron could be manufactured directly from the ore, more economically than by processes at present used. Of these, Renton's Furnace has been introduced into this State. It is situated in Newark, and was erected about five years ago, under the direction of the patentee, James Renton, for the American Iron Company, of that city.

It consists of two principal parts: first, a brick stack, sixteen feet high and thirteen feet square, enclosing a chamber, in which are placed a series of vertical fire-brick tubes, each twelve feet in length and five by eighteen inches in section; second, a puddling and welding furnace, with which the fire-brick tubes are connected.

The ore is introduced into the tubes at the top of the stack, after having been reduced to a state of great mechanical subdivision, resembling fine powder, and mixed with about twenty per cent. of charcoal dust as a deoxydizing or reducing agent.

The tubes, being filled, are left open at the top, and closed

at the bottom by a contrivance which enables the furnaceman to let the charge down into the puddling furnace at his pleasure.

The heat from the puddling furnace passes around the tubes in which the ore is inclosed, and raises them to a high red heat, by which the ore is exposed to a temperature sufficient to produce deoxydizement. After the ore has been exposed to the heat for about eighteen hours, it is let down into the puddling furnace, where it is welded or collected into a ball, and from thence taken to the trip-hammer or squeezer to be fashioned into a bloom, or prepared for the rollers.

The gases formed in the reduction of the ore make their escape at the open end of the tubes.

About two tons of iron are manufactured with one furnace, in twenty-four hours, when the ore is of good quality.

From the above description, it will be seen that the ore undergoes two successive changes: first, it is deoxydized by means of the carbon, and thereby reduced to a metallic state; and second, it is collected together in a ball suitable to be brought under the hammer.

It is evident that only ores in the form of oxides, and those in a pure state, are adapted to this process. Among the ores that have been most successfully reduced in this furnace, is the magnetic ore of the Dickerson mine. Ores of equal purity, from other mines in this district, would unquestionably work equally as well, but I am not aware that they have been tried.

The obstacles to the success of this furnace, in an economic production of iron, appear to be:

1st. The uniform purity and minute subdivision of the ore, required.

2d. The time and labor required in producing a ton of iron.

It is claimed, however, by its proprietors, that "the distinctive peculiarity and superiority of the furnace over all others is, that by its mechanical arrangement, the chemical change which is commenced and carried on in the tubes is

not interrupted until the ball is ready for the hammer, thereby reducing the manufacture of wrought iron into a practical, economical, scientific, and uniform system," and that the advantages of this method over the old modes, are as follows, to wit:

"The ores yield a greater per centage:

"The iron is more uniform, and of a better quality:

"It is made cheaper, and does not require such a heavy outlay of capital."

As I am not in possession of facts respecting the outlay in erecting this furnace, and the cost of producing a ton of iron, I am unable to judge of its merits.

CHARCOAL BLAST FURNACE.

Formerly, this kind of furnace was extensively used in the reduction of these ores; but since the introduction of anthracite coal in the manufacture of iron, and the great scarcity of charcoal, it has been almost entirely abandoned.

In eighteen hundred and thirty-two there were in the State twelve in blast; and at the present time I know of only two, viz: the Oxford and Wawayanda furnaces. The Oxford furnace is situated in Warren County, and is owned by Charles Scranton. The ore used in the furnace is derived from mines in the vicinity. The iron is manufactured into car wheels.

The Wawayanda furnace is situated on the Wawayanda Mountain, near the New York state line. It is of large size, and arranged with hot and cold blast. At the time it was visited the cold blast alone was used, because a superior article of iron was thus produced.

The ore is obtained from the mines bearing the same name, in the vicinity.

The following materials are consumed in producing a ton of pig iron:

Charcoal, - - - -	160 to 200 bushels.
Magnetic iron ore, - -	2 tons.
Limestone, - - -	0.25 tons.

They are introduced into the furnace at the tunnel-head, in charges; each charge consisting of eleven baskets of coal, (twenty-two bushels,) five hundred and twenty-five pounds of ore, reduced to a state of mechanical subdivision, about the size of hickory nuts, and from thirty to fifty pounds of limestone, the quantity depending on the quality.

From fifty to sixty charges are introduced in a day of twenty-four hours, yielding from seven to eight tons of iron.

The casting is done twice a day—at noon and at midnight.

The iron is considered peculiarly adapted to the manufacture of car wheels, and is chiefly consumed by Whitney & Son, of Philadelphia, for this purpose.

The ores of the principal mines throughout this district, in former days, have been extensively reduced in these furnaces. The iron manufactured therefrom has been of excellent quality, as the various uses to which it has been applied will testify.

ANTHRACITE BLAST FURNACE.

The introduction of anthracite coal in the manufacture of iron, has done much for the advancement of the iron industry in this country, and must ere long place it beyond foreign competition.

The application of this coal for the reduction of rich magnetic ores, was first made by Mr. Edwin Post, who erected a furnace at Stanhope and commenced the manufacture of iron from the Irondale ores.

This experiment soon led to the erection of anthracite furnaces in the vicinity of the coal-fields of Pennsylvania, which, to this day, have obtained a large proportion of their ores from New Jersey—the idea being entertained that the iron manufacture could be more economically prosecuted by transporting the New Jersey magnetic ores to the coal-fields, and there smelting them, than by the transportation of the coal into the iron region. The prevalence of this idea has been the means of delaying the erection of anthracite furnaces in this State; but under the influence of increased and

still increasing facilities for transportation, the time has arrived when the manufacture of iron may be as economically prosecuted in the iron region of this State as in the coal districts of Pennsylvania.

The principal anthracite furnaces of this State in which the magnetic and specular ores of this district have been worked, are four—three of which are situated at Phillipsburgh, on the Delaware River, in Warren County, and one at Boonton, in Morris County.

The furnaces at Phillipsburgh are of very large size—two of them fifty-five feet high, hearth seven feet, tunnel-head ten feet, and bosh twenty and twenty-two feet. The smallest one is forty-two feet high, hearth seven feet, tunnel head eight feet, and bosh eighteen feet.

The largest furnace, viz.: fifty-five feet high and twenty-two feet bosh, works much better than those of lesser dimensions; it requires less fuel and labor in producing an equal quantity of iron.

To the present time the three furnaces have produced ninety-six thousand tons of pig-iron. Their average weekly yield is five hundred tons. The maximum weekly yield of one furnace is two hundred and fifty-one and a half tons. In the smallest furnace, two hundred and thirty tons have been made per week, for six weeks in succession, with one and a half tons of coal per ton of iron.

The ores consumed in these furnaces have been obtained chiefly from the Andover mine, nearly two hundred thousand tons having already been consumed. The ores of the Roseville, Dickerson, Allen, Hibernia, Irondale and Ringwood mines have also been used alone, as well as mixed with Andover ores.

At first, under the impression that Andover ore would not work well alone, it was mixed with hematite ore, in different proportions; but it was soon ascertained that the Andover ore worked better and made a superior iron to the mixture, and the hematite was consequently abandoned.

The coal is that variety of anthracite known as Lehigh coal, and was obtained from Mauch Chunk.

The flux is a magnesian limestone obtained from the quarry within a few hundred yards of the furnaces.

The pig iron produced at the furnaces is puddled with anthracite coal, at the rolling mill of the company, at Trenton, and the blooms thus made have been manufactured into the various kinds of bar iron, railroad iron, wrought iron beams for fire-proof buildings, wire of different sizes and of the finest quality, shafts of great strength and toughness for large class steamers, and steel of superior quality.

The following materials are consumed in producing a ton of iron, in the use of the above ores, respectively :

ANDOVER MINE.

Andover ores, (specular,) - - -	2.25 tons.
Coal, - - - - - -	1.75 "
Limestone, - - - - -	0.25 "

The iron is similar to that produced from the franklinite ore, being highly crystalline, and in its fracture having a bright metallic lustre, resembling that of antimony. A large proportion has a foliated structure, being crystalized in laminæ; another variety has a fibrous structure, the fibres radiating from the centre to the outside of the pig; and another variety has a granular structure, the grains being coarse and crystalline.

It is considered, for many purposes, superior to iron manufactured from magnetic ores, on account of its crystalline structure, caused by the presence of manganese and a more intimate union of the carbon and iron.

ROSEVILLE MINE.

Magnetic ore, - - - - - -	3 tons.
Coal, - - - - - - -	2.5 "
Limestone, - - - - - -	0.3 "

The small proportion of limestone required is owing to the prensence of carbonate of lime mixed with the ore.

The iron is red-short, but it is soft and very fine grained, and is well adapted to foundry purposes.

It has been advantageously used in the manufacture of

kettles for trying out whale oil, and for this purpose has gained considerable notoriety.

RINGWOOD MINES.

Magnetic ore, (assorted,) - -	1.75 tons.
Coal, - - - - - -	1.75 "
Limestone, - - - - -	0.65 "

DICKERSON MINE.

Magnetic ore, - - - - -	2 tons.
Coal, - - - - - -	2 "
Limestone, - - - - -	0.8 "

The iron is cold-short, even when mixed with one-fourth Andover ore, but makes a good foundry iron.

ALLEN MINE.

Magnetic ore, - - - -	2.25 tons.
Coal, - - - - - -	2 "
Limestone, - - - - -	0.5 "

The iron is slightly inclined to red-short, but makes a good forge iron, and when mixed with one-fourth Andover ore, produces a superior article, equal to the Andover iron.

HIBERNIA MINES.

Magnetic ore, - - - -	2 tons.
Coal, - - - - - -	2 "
Limestone, - - - - -	0.4 "

This iron is similar to that produced from the Allen ore.

In the use of the above ores, the following results have been obtained:

1. Ores containing apatite, (phosphate of lime,) produce a cold short iron.

2. Ores containing iron pyrites, (sulphuret of iron.) produce a red short iron, but suitable for foundry purposes.

3. Ores containing manganese produce a hard crystalline iron, which is neither cold nor red-short, but of great tenacity.

4. Ores 1 and 2, or 1 and 3, or 2 and 3, mixed in suitable

proportions, produce a neutral iron, suitable for forge purposes.

THE BOONTON FURNACE.

This furnace is forty feet high, fourteen feet bosh, five feet tunnel-head and hearth, and has six tuyeres.

Its average annual production is 6,000 tons of pig iron. In 1855 it produced 6,179 tons.

The ores used are exclusively the magnetic ores of Morris County, chiefly from the Sweeds and Mount Pleasant mines.

The flux is magnesian limestone, obtained chiefly from Hackettstown, in Warren County, and Montville, in Morris County.

The coal is anthracite, and of the Lehigh variety.

The following quantities are consumed in producing a ton of pig iron :

Magnetic ore, - - - - -	2 tons.
Coal, - - - - - -	1.87 "
Limestone, - - - - -	.06 "

The Sweeds ore produces a red-short iron, and the Mount Pleasant ore a cold-short; but when mixed as they are here used, they produce a neutral iron of excellent quality, and admirably adapted to the purpose for which it is applied.

The pig-iron is puddled at the works adjoining the furnace, and the blooms thus made are rolled into nail-plates and rods, which constantly employ one hundred and nine machines in manufacturing nails and spikes; of which, during the year 1855, 146,445 casks, of 100 pounds each, were produced.

ANTHRACITE FURNACE FOR REDUCING FRANKLINITE ORE.

In connection with the metallurgy of the magnetic and specular varieties of iron ore, may be included the franklinite ore, which, until Mr. Edwin Post reduced the ore with anthracite coal, at Stanhope, and thereby demonstrated the application of that fuel to its reduction, has resisted all attempts to its introduction in the manufacture of iron.

I regret that I am not in possession of details respecting the "modus operandi," and the results of this experiment, in order to give a minute account of it, and thus render to Mr. Post the credit to which he is entitled for this valuable contribution to metallurgical science.

Since Mr. Post's experiment, two furnaces have been erected for the reduction of this ore, one at Newark, at the zinc works of the New Jersey Zinc Company, and the other at Franklin, in the vicinity of the deposit of ore. The former was erected for the purpose of reducing the residuum (chiefly franklinite) of the zinc furnaces; the latter, for reducing the ore as it occurs in its native bed at Franklin, Sussex County.

THE NEWARK FURNAC.

This furnace was erected under the superintendence of Mr. C. E. Detmold, (late President of the New Jersey Zinc Company,) during the autumn of 1855. It is a small anthracite blast furnace, twenty feet high, eight feet bosh, and four and a half feet tunnel head.

It has three tuyeres, and is arranged with hot blast. It is made of fire-brick, enclosed by a sheet iron mantle and strengthened by wrought iron bands.

The furnace is surmounted by a chimney, ten feet high and four feet six inches square, with three doors for charging the furnace. Near the top of the chimney is an opening four feet in diameter, through which the zinc passes into a sheet-iron pipe leading to the fan. The mouth of the chimney is closed by four dampers, which may be raised whenever the zinc and gases do not pass freely into the pipe.

The ore from which the residuum is derived, is a mixture of franklinite and red oxide of zinc. The zinc is extracted in the form of the white oxide, by a process of sublimation; the ore having been crushed and mixed with a portion of fine coal as a reducing or deoxydizing agent, and then subjected to a high temperature in closely muffled furnaces, which causes the vapor of zinc to be evolved and consequently re-oxydized, in which state it is used as a paint.

The residuum obtained by this process, is composed chiefly of franklinite and carbon, in the form of a fine powder, resembling fine sand.

The fuel employed is anthracite, and the flux oyster shells.

The following quantities were consumed in producing a ton of pig iron:

Residuum,			2.90 tons.
Coal for furnace,	2.10 tons.		
" " boilers,	1.10 "		
" " hot blast,	0.16 "	—3.36	"
Oyster shells,		0.43	"

For every ton of pig iron produced, one hundred and thirty-six pounds of the oxide of zinc were collected; and as the arrangement for allowing the escape of the zinc and gas was not sufficient to carry them off, it was found necessary to keep open one or two of the dampers at the mouth of the chimney, through which a large proportion of the zinc escaped and was lost.

When the furnace was in good order, the production of pig iron was from thirty to forty tons per week; the residuum yielding from thirty-three to thirty-seven per cent. of iron, and the coal consumed *in the furnace* from one and a half to two tons per ton of iron. After the furnace had been in blast twenty-one weeks, one of the boilers failed, which rendered it necessary to "blow out" the furnace.

During the twenty-one weeks it was in blast, it consumed:

Residuum,		1631 tons.
Coal for the furnace,		1165 "
" " heating boilers,		607 "
" " hot blast,		88 "

Its production was:

Pig iron,	552½ tons.
Oxide of zinc,	77,255 lbs.

THE FRANKLIN FURNACE.

This furnace was erected by the New Jersey Franklinite

Company, and put in blast in the winter of 1854. It was in operation only a few weeks, owing to some imperfection in its construction and the inexperience of the workmen "in the combined operation of smelting iron and collecting zinc oxide."

It is a small blast furnace with hot blast, and arranged with a chimney at the tunnel-head, with which a pipe is connected for conveying the zinc oxide to a condensing chamber.

Although the furnace was in blast but a short time, yet sufficient data were obtained to satisfy the company that the franklinite ore can be economically smelted, yielding two products, viz: a superior article of pig iron and the oxide of zinc.

The ore used was taken from the great metalliferous deposit in Mine Hill, and considered of a mixture of franklinite, red oxide of zinc and willemite, (sillicate of zinc.)

The following is an account of the working of the furnace for two weeks, ending March 25, 1855. During a part of this time the zinc oxide was not collected, on account of a deficiency of power to work the fan:

Ore used,	102.50	tons.
Coal,	137	"
Limestone,	25.20	"
Iron made,	22.90	"
Oxide of zinc made,	22,084	lbs.

The iron produced from the franklinite ore is of a very peculiar quality and excellency. It is particularly adapted to the manufacture of steel and malleable iron, and hence commands a higher price than pig iron manufactured from other ores of iron. Dr. A. A. Hayes, of Boston, has analyzed a specimen of iron produced at the Franklin furnace. The following extract is taken from his report thereon to the company:

"In general physical characters, the sample resembled 'white pig iron,' but a closer inspection shows a different molecular arrangement, by which the crystals are affected

in form and distinctness by chemical dissection. The mass of iron exhibits *two* distinct crystalline aggregations; the broad folia of one of these being separated by thin lamina of a different color, hardness and composition, in this respect resembling meteoric iron. The color of the specimens is nearly that of the finer samples of metallic antimony; the masses divide easily, but the angles and edges of the imperfect crystals are harder than the hardest cast-steel, and in the attempts to obtain a powder, they became embedded in its surface; a mean specific gravity is at 60 F. 7.665. Electrically, it presents a positive part, closely invested by a relatively highly negative body. Chemically, its characters are of an imperfect steel; its carbon constituent is in the state of that which has been deposited from carburetted gases by a high temperature, and has no properties in common with graphite.

"No trace of sulphur was found. A trace of phosphuret of calcium could be detected, but neither zinc, chromium, vanadium, or copper could be found. Associated with the carbon in an accidentally earthy manner, derived doubtless from the slag, and in this is a minute quantity of unreduced franklinite. This occurrence of ore in iron I have often noticed in samples which *do not* present graphite. There was no evidence of the existence of the metallic bases of the earth's either.

ANALYSIS.

"In the following statement the iron is presented as a simple alloy, consisting in one hundred parts of

Pure iron, - - - - -		93.364
" manganese, - - - -		3.204
" carbon, - - - -		2.250
Slag, silica, - - - -	.640	
Ore and alumina, - - -	.240	
Lime, - - - - -	.170	1.050
		99.868

"The mechanical and chemical constitution of this iron point to great ease in working it into malleable iron. Both the manganese and carbon are readily oxidized by the puddling, while the pure iron will take the form of tough or malleable iron very readily. It is also the kind of metal required for manufacturing steel, by fusion with oxide of manganese, losing in the operation a portion of carbon and all its metallic manganese."

An essay of a bar of franklinite iron, manufactured at Stanhope, by Mr. Edwin Post, was made at the French National Establishment, for the manufacture of chains and anchors for the navy, by Mr. Theophile Bornet, chief of the works, and author of the "Tables of the Strength of Metals."

"REPUBLIQUE FRANÇAISE."

ADMINISTRATION DE LA MARINE."

FORGES NATIONALES DE LA CHASSANDRE.

Essay of a bar of iron from a new ore, THE FRANKLINITE, *from New Jersey, United States:*

The bar, obtained by direct treatment of the ore in a catalan forge, is 25 millimetres by 24.5 millimetres square, and presents a section in square millimetres of - - -	612.50 *m.*
Charge under which the bar began to stretch,	15,000 *k.*
Elastic force, per millimetre, - - -	24.5 *k.*
Charge under which the bar broke, - -	25,000 *k.*
Absolute tenacity, per millimetre, - -	40.8 *k.*
Elongation of the bar at the moment of fracture, per millimetre, - - - - -	5 *m.*

Aspect of the fracture—all nerve. The bar was imperfectly welded, and contained fissures which diminished the real surface exposed to traction; in consequence, the *absolute tenacity*, had the bar been sound, would have been greater. At the moment of rupture, but little heat was disengaged.

"After Crane's success, new efforts were made; and it is to be recorded to the honor of Nicholas Biddle, that he was among the first to contribute his money and his influence to the successful prosecution of the business. To another of our New York citizens, Edwin Post, Esq., who brought great intelligence, capital, and indomitable perseverance to the task, is due the honor of having first smelted successfully our rich magnetic ores with anthracite coal, at Stanhope, N. J., as he has since succeeded in reducing the fossiliferous hematites believed to be entirely refractory.

"From the time of the application of anthracite coal, the historian will date the birth of the American iron business. Its great density and purity fit it peculiarly to our rich ores; so that while in England, with three years the start of us, the produce of anthracite iron had reached only one hundred and forty thousand tons in 1855, in this country it amounted to at least three hundred and sixty thousand tons; showing that, where an approach to an equality of the elementary conditions can be realized, there are lacking in this country neither energy nor skill to take advantage of the opportunity to achieve a successful result.

"**The increase of capital in this country, and especially in the hands of the iron-masters, will overcome one of the artificial advantages which the English have heretofore possessed over us. At present, capital is unusually dear in England, and the course of trade, and the better knowledge abroad of our resources, are doing much to equalize the value of capital, and to remove one of the most serious difficulties in the way of the progressive growth of our domestic manufactures.**

"But at the periods of low prices, the English maker does not require so much capital, because his labor is cheaper, and his iron therefore costs less.

"It is certain, however, that within the last ten years the disparity in the wages of labor in the two countries, has been greatly reduced, not by any fall in the price here, but in the increase of the price in England. And it would seem reasonable to anticipate that, with the present rapid and cheap

intercourse between the two continents, an equalization in the rewards of human industry would inevitably take place, and every step towards such an equality is in favor of our production of iron on terms of equality in every respect.

"It is apparent, then, that the only reason why iron *now* costs more to make in this country, is the greater value of capital and labor, and that there are natural laws at work, slowly but surely sapping at the roots of these obstacles. But it may be alleged that it will require too long a time to equalize these conditions, and that it is better to abandon the business now, and wait till these desirable changes have actually been realized. To say nothing of the ruin which this course would entail upon those who are now engaged in the business, and who have nursed it to a condition where it no longer requires the aid of any duties beyond what the revenue of the general government demands; to say nothing of the loss of skill and machinery, which twenty years of sacrifice would not replace; I think that another natural law is at work, which will soon place us beyond the aid of tariffs or the fear of competition—a law which, overcoming the extra cost of labor and capital, insures to us that iron will be produced here at an early day as cheaply as it can possibly be got from Great Britain, even if entire free trade be allowed. If such be the fact, to discriminate against the iron trade, to deny to it the revenue duties which are imposed upon other articles of import, would be the height of folly; for the business would be ruined, and the country would save no money and vindicate no principle by such legislation.

"Let us see what this law is. I have been at great pains to trace the increase of the consumption of iron by the world, and to form an accurate idea of its future demands. I have called your attention to the fact that, even now, the resources of Great Britain have been so taxed to meet the existing demand, as to increase *the cost* of iron, (I do not mean the price,) because the miners are driven to less favorable localities to procure adequate supplies of raw material. If the production of three and a half millions of

tons per annum has made each ton cost more than it did when the production was only two millions, the addition of another million must have a corresponding effect. But the world will want and must have the other million, and two of them, and three of them, and, unless other countries aid in the supply, the price will rise far above our present cost of production. It seems to be the inevitable conclusion of the facts I have stated, that this day is not far distant. Even now, we can make iron at the *average price* of English iron, and if we make none, that average price would be higher; so that there is no reason to believe that iron would be sold for less than it now is, if it all came from England. But let it be noted that the American iron-master now asks for no special legislation in his behalf; but he objects to any legislation, and very properly, which excepts him from whatever incidental advantage there may be in the fair imposition of duties for revenue. Heretofore, in times of great depression, long continued, he has felt the want of financial or legislative corks to float him over these 'sloughs of despond,' and it is at such times, and such times only, that you have heard him, a drowning man, conscious that he has many years of life in him, if he could only touch a buoy for a short period, calling on Congress for temporary relief, or entreating that the slight prop between him and ruin might not be knocked away. Now, however, he feels that the steadily increasing demand of the world for iron, and the fact that England cannot supply the whole of it without a decided increase in cost, insures to him that soon, aside from the question of capital and labor, these periods of extreme depression will either cease to occur, or if recurring at all, will continue for such short intervals that he can sustain himself till the improvement takes place.

"I have been thus careful to show that this day the possession of adequate skill, of extensive and properly constructed works, of a large body of intelligent workmen, of great natural resources in the way of raw materials and channels of communication, and of equally great ones in the canals and railways which the genius of our age and people

have constructed, makes legislation for the purposes of protection no longer necessary, because I regard the days of protection, for the sake of protection, as passed away. I have been equally careful to show that the artificial elements of dearer labor and capital do not make us independent of a fair share of those duties which are necessarily imposed for the raising of national revenue, but that there are causes at work which promise soon to make us independent even to this aid, to which we have a fair claim in the balance of national interests; because, under this state of fact, intelligent and influential men, identified with our great railway interests, have combined together in the short-sighted policy of demanding a remission of the duties on railroad iron at a time when it has been demonstrated, and is admitted by all experienced engineers, that our American rails are more durable than the foreign rails, and consequently worth more by the whole amount of duty paid. They have made this movement at the very time when the facts and probabilities all favor the conviction that the steady approach to the equalization of the elementary conditions of cost in the two countries, will soon place us on a par with our only competitors.

"We can point with pride to the fact that we have passed the half-way point; and if the business is not struck down by legislation expressly leveled at its destruction, in less than two years we shall be able to supply the whole wants of the country.

"Having thus traced the progress of the trade in this country, and shown that its difficulties are only artificial and temporary, it only remains for me to investigate the geographical elements of our present make of iron, and to show in what parts of this great country are, and will be, the seats of production.

"The Delaware, with its main branch, the Lehigh, reaches into the coal region. The secondary ores abound along its shores, while the Morris Canal has made the great primitive ore resources of New Jersey easily accessible. Hence the earliest successful efforts to make iron with anthracite coal

on a large scale occurred in this region, and from the cheapness of the raw materials, it must be the leading seat of the iron trade on the Atlantic slope. New York is the natural outlet for this region, and our far-seeing capitalists have already made provisions for it by the construction of direct lines of canal and railway. The product of this region in 1855, was about one hundred and forty thousand tons, including, as I always do, the make of wrought iron direct from the ore."

Mr. Hewitt, in his valuable paper, above quoted, has demonstrated that the increasing iron consumption of the world will soon overtask the national resources of Great Britain, and that no other country but the United States can make up the surplus in the main. This, together with the rapidly increasing consumption of the United States alone, will ere long place this branch of industry the foremost in our country, in which New Jersey must take a very active part, not only in furnishing the raw material, but in the manufacture of the iron therefrom.

WILLIAM KITCHELL.

REPORT ON THE PROGRESS

OF THE

GEOLOGICAL SURVEY,

OF THE

SOUTHERN DIVISION OF THE STATE,

DURING THE YEAR 1856.

To Dr. Wm. Kitchell, *Superintendent of the Geological Survey of New Jersey:*

Sir:

I herewith submit my report on the progress of the Geological Survey in the Southern Division of the State, for the year 1856.

Your obedient servant,

GEO. H. COOK,

Assistant State Geologist.

Rutgers College, New Brunswick, Dec. 26, 1856.

REPORT.

The Geological Survey of the Southern Division of the State has been continued, either in the field or in the laboratory, during the entire year.

The final report on the geology of the county of Cape May has been finished, and is now in the printer's hands. It is expected that it will be published in the early part of January.

In regard to this county, it may be stated, that although there is but little variety in its geological formations, and though it has no mineral wealth, it has in its soil and climate peculiar advantages for agricultural improvement. The price of land is low and a large portion of the best soil in the county is still unimproved. Considerable space has been occupied in describing the different fertilizers which are found, and in detailing the methods by which they may be made useful. The agricultural resources of Cape May, when properly developed, will add largely to the wealth of the state; and it is hoped that the geological and agricultural report, with the topographical map of the county, by Lieutenant Viele, will render important service towards this object.

Several contributions have been made to the Cape May Report, which add materially to its interest and value. Thos. Beesley, Esq., of Dennisville, has furnished a List of the larger Wild Animals of the county, and a very full Catalogue of its Birds. He has also commenced collecting birds for preservation in the State Cabinet. Professor Spencer F. Baird, of the Smithsonian Institution, Washington, has fur-

nished a Catalogue of the Fishes of the New Jersey shores. Samuel Ashmead, Esq., of Philadelphia, has contributed a set of beautifully preserved specimens of the Marine Algæ of our sea-shore, with a Catalogue; also a List of Flowering Plants collected about Beesley's Point, together with specimens of a part of them. Dr. Maurice Beesley, of Dennisville, has written for the volume an interesting and carefully authenticated "Sketch of the Early History of the County of Cape May." I take pleasure in calling attention to the valuable and generous assistance which these gentlemen have rendered to the survey.

Neither can I, in justice, omit to acknowledge the useful assistance and the hospitality which I everywhere received.

§ The survey of Monmouth County is nearly completed. A large number of marls have been analysed for the final report, and levels have been taken for the proper construction of geological sections. Much material in relation to its agriculture has also been collected; and the principal work remaining, is to delineate the geological formations upon the map of the county, and to write the final report. These can be accomplished in a short time after the map is received. From the report of the topographical engineer, Lieutenant Viele, it will be seen that his field operations in Monmouth are completed, and the map may be expected soon.

§ In Cumberland County, all the townships have been partially examined; specimens of soils have been collected, also of marls and other fertilizers, and full notes of the agricultural practice and capabilities of the county have been made. The laboratory work is commenced and every preparation is made to carry the survey of the county forward with dispatch.

§ All the remaining counties in the Southern Geological Division of the state, have been visited; examinations of the geological formations have been continued; collections of fossils, soils and fertilizers have been made to some extent from each of the counties. Especial attention has been given to agriculture, and it is hoped that a beginning has

been made towards collecting and embodying, in available form, the successful practice of our best farmers.

§ The Southern Division of New Jersey, on account of some of its mineral deposits, as well as from the numerous and enormously large fossil bones and shells found in them, has long attracted the attention of geologists. Up to the year 1827, it had generally been spoken of as an alluvial formation. Some had designated it as tertiary. In that year Mr. Vanuxem and Dr. Morton, from facts which they had collected, came to the conclusion that the *marl* or *greensand* of this state was of the same geological age with the cretaceous formation of Europe. Subsequent investigations have confirmed the opinions of these gentlemen.

As the principal representative in our country of the cretaceous formation, various localities in the marl region have been much resorted to by geologists for the purpose of collecting its peculiar fossils. The inhabitants have also been in the habit of preserving some of the fossils, to give to persons who might esteem them as curiosities. In this manner the fossils have been very extensively scattered; and while some of them have found their way into cabinets of geology, the majority of the specimens, including among them many that were rare, have been lost to science. Of the specimens which have been preserved in cabinets, many are without any localities, being only labeled as coming from New Jersey.

With the discovery of the cretaceous formation in other parts of the United States and territories, renewed attention has been drawn to our own deposits of this formation, and it is felt to be a matter of much importance to know as many as possible of the fossils found here, in what subdivision of the marl stratum they are found, and their precise localities, so as to trace out, by comparison, the equivalents to these subdivisions, in other and remote places.

All the fossil shells and corals which have been collected in the course of the survey, have been placed in the hands of Professor James Hall, the distinguished palaeontologist,

of New York, for description. Professor Joseph Leidy, of the University of Pennsylvania, and eminent as a comparative anatomist, has the fossil bones and teeth for description. These gentlemen have found many new species among the specimens, and of those which are known, they find many better specimens than have been seen before. Much interest is felt by them to have the collections made as complete as possible before the descriptions are published.

I have made exertions to secure all the specimens I could for the state cabinet, and where this was not possible, to borrow them for description. Many gentlemen have lent their aid in furtherance of this object. Dr. Knieskern has been indefatigable in making collections at Shark river. Valuable collections of bones and shells have been given to the state by John S. Cooke, of Tinton Falls, by Rev. G. C. Schenck of Marlboro, Thomas B. Jobes of New Egypt, M. T. Rue near Perrinesville, Henry Aregood of Kincora, J. J. Hummell of Shiloh, and others. Interesting specimens have been lent to the state by Professor O. R. Willis of Freehold, Mr. Hopper of the same place. Rev. Mr. Finch of Shrewsbury, Rev. Mr. Lockwood of Keyport, Mr. Elnathan Davis of Jericho, and others. Not having the fossils here, I am not able to give the names of all who have favored the survey, by the gift or loan of specimens, but it is intended that due acknowledgement shall be made to all in the published descriptions.

The fossils are obtained in digging the marl, and of course can only be got through the favor of those who own or work the pits. A little effort on the part of those located in the marl districts, in preserving specimens, might greatly enrich our state cabinet, and add materially to the stores of science. Every year valuable fossils which are dug out, are destroyed or given away as curiosities, to those who attach no scientific value to them; and they are, for all useful purposes, lost. I would earnestly appeal to that feeling of state pride which every true Jerseyman should possess, to enlist citizens in collecting and saving specimens to form a

cabinet, which shall properly represent the fossils of the state.

§ Accompanying this report, is "A Catalogue of Plants growing without cultivation in the Counties of Monmouth and Ocean, by P. D. Knieskern, M. D." This catalogue gives the names of seven hundred and eighty-one species, and a number of varieties, all "plants found and examined by" Dr. Knieskern, "within the last ten or twelve years." He says, "There are doubtless many plants that may still be detected within our limits, not included in this catalogue, especially in the portion farthest from the coast, which has not been examined as thoroughly as the pine barrens and the region bordering on the ocean."

It is desirable to publish in the final reports, as complete a list as possible, of plants growing in the state. By circulating this catalogue among botanists, so that our present deficiencies may be known, additions can be obtained from different parts of the state, and in this way it will be put in condition for final publication.

It is requested that this catalogue be printed in pamphlet form, separate from the report, for the use of Dr. Knieskern and the officers of the survey.

PRESENT CONDITION OF AGRICULTURE IN NEW JERSEY.

In prosecuting the survey of Cape May County, it was found that the advancement of its agriculture had been so great since the United States census of 1850, that the statistics of the Census Report gave a very inadequate idea of the amount of its agricultural productions, at this time. By the favor of the Assessors in the different townships, I was enabled to get accurate statistics, for the present year. The result is truly gratifying; it shows an advance in the agricultural products of about fifty per cent. since 1850, and the price of land has nearly doubled.

No statistics have been collected in the other counties; but from observations in the southern half of the State, I am well satisfied that the spirit of agricultural improvement is

more active in almost any of the other counties, than in Ca
May; and that the progress which is making is quite
rapid as it was between 1840 and 1850. (See tables A a
B in the Appendix.)

The advancement made in New Jersey during that perio
when viewed in comparison with that of the neighborin
States, Connecticut, New York, Pennsylvania, and Del
ware, was very flattering. In the staple crops, of wheat an
Indian corn, we show an increase of more than one hundre
per cent. which is more than double that shown in either
the other States, and in potatoes a gain is shown of seventy
nine per cent. against a gain of fifty-two per cent. in Delawar
and losses of twenty-two, forty-nine, and thirty-seven pe
cent. in the States of Connecticut, New York and Pennsyl
vania. Other crops show a fair advancement in the com
parison, the particulars of which may be seen by a referenc
to the tables.

In the aggregate crops of wheat, rye, oats, Indian corn
potatoes, barley, and buckwheat, if the amount for eac
State is taken, and averaged among the whole number o
acres in each State, it gives for New Jersey, four and twenty
one hundredths bushels per acre; Connecticut, two and twenty
four one hundredths bushels per acre; New York, two an
seventy-eight one hundredths bushels per acre; Pennsylvania
two and forty-one hundredths bushels per acre; and for Dela
ware, three and thirty-six one hundredth bushels per acre
There is also a very large balance in favor of New Jersey in
products of orchards and market gardens. In the products o
the dairy the balance is against us in the article of cheese
In live stock there is no great difference in the several States
It is remarkable that there is a diminution in the amount o
stock kept in all the States above mentioned.

The comparison furnishes a most satisfactory vindicatio
of our State, in its soil and productions, from the aspersion
which it is so fashionable for some of our neighbors to cas
upon it.

New Jersey occupies a location for markets, unequalle
by any other State in the Union. Lying between th
great commercial centres of our country, New York an

Philadelphia, and having within her own borders much mechanical and manufacturing industry, a ready market for all her products is ever open; almost surrounded by navigable waters, penetrated at numerous points by rivers and creeks, and crossed by several railroads and canals, she possesses great facilities for quick and cheap transportation; so that for bulky, heavy or perishable articles she might have almost a monopoly of the markets.

Her soil, it has been well said by one of our citizens, in comparing it with that of a neighboring state "is easier tilled, equally productive, less liable to suffer from sudden changes of wet and dry, imbibes more freely the sun and dew, to favor the growth of early fruits and vegetables, and ripens them sooner for market."

With marls, limestones, and other fertilizers in great profusion within the State; with fish, crabs, and other matters, the spoils of the sea, upon her borders, and with contiguity to large cities and cheap means of transport for their waste manure and offal, New Jersey possesses unequalled resources for cheap and abundant fertilizers.

The success which attends good farming is perhaps the best evidence that can be adduced for our agricultural advantages. It has been shown from the census tables, that our product per acre, where the whole area of the State is taken into account, considerably greater than in any of the adjoining States. If the separate crops are taken, the average for corn, oats, and potatoes is higher than in the States adjacent; our wheat and rye are put down as yielding a smaller crop per acre, which, as an average, is undoubtedly correct. The premium crops of wheat, in all the counties where there are agricultural exhibitions, have been above thirty bushels an acre, in some of the counties they have been above forty bushels an acre for several years in succession, and there are instances in which crops of fifty bushels, or upwards, per acre have been harvested. The practice is much more common in this State than in others, of sowing wheat and rye in corn, or after corn or potatoes. A diminished crop of grain is the necessary consequence of

this mode of cultivation; though the produce of the field and the profits for the year are increased thereby. Wherever there is thorough cultivation the crops of grain are not inferior to those raised in other states. But it is in fruits, and in market-garden produce that our greatest advantages are found.

The returns for an acre of strawberries are from one hundred dollars upwards. The Burlington County Agricultural Society, in 1855, awarded the premium for the most profitably cultivated crop in the county, to one of strawberries. It yielded at the rate of twelve hundred and twenty-two dollars an acre, clear profit. Cranberry fields are known which annually yield to their owners three hundred dollars an acre. Large profits are also obtained from the cultivation of other small fruits. The state is noted for the production of apples and peaches, and fortunes have been made in their cultivation. Market-gardening pays well to those who engage in it. Early potatoes, which yield one hundred dollars an acre, are common, and those yielding three times that sum are not unknown. Equal profits can be obtained from the cultivation of sweet potatoes.

And yet with all these advantages and the examples of the large profits mentioned, to be found in all parts of the state, there are still two million acres, or nearly one half of the state uncultivated. Not entirely waste, it is true, but only yielding crops of wood, every fifteen to thirty years, which in growth may average a cord, a year, for each acre, but which on account of fires, late frosts, &c., probably produce to the owners, not half that amount.

In view of the facts presented above it is astonishing that so little attention has been paid to these unoccupied lands. The greater portion of them are not lighter or poorer than other soils from which persevering and skilful husbandry is now drawing the largest and most certain returns. And they offer the great advantages of healthy locations, and contiguity to the older settled portions of our country.

The large body of uncleard land, which occupies the central portion of southern New Jersey, is narrowed on all

its borders, every year by the inroads of the farmer, and many large and productive farms are now found, where but a few years ago there was only unbroken forest.

Could the productiveness of these lands be generally known, and were they properly opened to markets, by means of roads and railroads, it would be the means of saving to the state every year, hundreds of useful citizens who now leave us to seek new homes in the west.

In regard to one of our staple crops, the potato, the Census Reports furnish some important facts. The general result of a large increase in the yearly product of New Jersey, of an increase in the product of Delaware and a diminution in that of Connecticut, New York, and Pennsylvania has been mentioned. On comparing the product of our state by counties, it appears that the increase was mostly in Monmouth, Burlington, Camden, Gloucester, Salem, and Cumberland, the counties in which marl is found, while in the remaining southern and middle counties of the state the increase is small, and in several of the northern counties there is a material diminution of the crop. (See table C in the Appendix.) So too, in the state of Delaware, the largest crop, and I presume, the largest increase of Irish potatoes, is in New Castle county, in which marl is found. In the state of New York there was an increase in only three counties, and these were the three constituting Long Island; and of these three the largest increase was in those, which there is some reason to believe, lie in the same geological formation, with those counties in New Jersey, in which there was the largest increase. In Connecticut there was an increase in Middlesex county, which lies in the valley of the Connecticut river, and at its mouth. In Pennsylvania there was a small increase in eight counties, located in the eastern part of the state, and mostly on the Delaware river, and its branches. Of the states in which there was no greatly increased population from immigration, New Jersey and Delaware were the only ones in which there was not a diminution of the crop of Irish potatoes between 1840 and 1850. By a reference to table C, it will be perceived that there has been a moderate increase of the crop

in the sandy and light soils where marl has not been used: but the large increase is confined to the counties in which marl exists as a constituent of the soil, or is used as a manure.

The fact of this remarkable difference, in favor of our marl districts, is that which mainly concerns the practical farmer, but the cause of it cannot but be interesting to reflecting minds. Whether its special action is due to some component of the marl, or whether its usefulness is partly owing to the mingling of new earth, taken from beneath the surface, with the soil, is a question not easily answered. There is no effect produced on the appearance of the potato top. The crop, of choice varieties, is from seventy-five to one hundred and fifty bushels an acre, The potatoes are of good size, smooth and smoth-skinned, of superior quality for the table,* and not subject to the potato rot. The marls which are least esteemed for permanent improvement of the land, produce quite as good effects upon a single crop of potatoes as those which have the highest reputation. The Cumberland marls, which are not green sands, are deemed almost indispensible to this crop, and they produce potatoes of an excellent quality; though I think the average crop per acre is somewhat less than where green sand marl is used.

The value of this crop makes a large item in the whole agricultural product of the state. In an article in the New Jersey Farmer, for December, the potato crop of Monmouth county for the present year, is estimated at thirty-three per cent. more than that of 1850; or, in round numbers, at one million and fifty thousand bushels, and the average price as over seventy-five cents a bushel. At that price the whole crop would be worth seven hundred and eighty-seven thousand, five hundred dollars. The crop of the state may be safely estimated at four times this quantity, which in value would be three million, one hundred and fifty thousand dollars.

FERTILIZERS.

The abundant supplies of fertilizers found in our state

* Potatoes from the marl region will bring fifty cents a barrel more than others in the New York market, and then have the preference.

are attracting more and more of public attention. The green sand marls are getting to be used over larger districts of country, and they are gradually finding their way to more remote markets.

There has been sent over the Freehold and Jamesburg Agriculturul Railroad, during the past year, 270,982* bushels of marl, all of which has found a market out of the marl district, and some of it out of the state. The high state of agricultural improvement along the lines of railroad, where this marl is distributed, is sufficient evidence of its value. An association called the New Jersey Fertilizer Company, has opened marl pits on the shore of Sandy Hook Bay, near Riceville, and have built a wharf for the purpose of shipping the marl of that locality. From this point marl can be very easily obtained by farmers along the shores of our own and the neighboring states. Marl is also dug extensively at White Horse, in Camden county, on the line of the Absecom Railroad, and the marl is delivered at places along the road throughout its whole length, greatly to the advantage of the country through which the road passes and to the state. The Delaware and Raritan Bay Railroad, which is now in process of construction, passes through the rich marl regions of Monmouth county, and when completed will open a large district of our state to the benefits of this valuable fertilizer, and will furnish a convenient outlet for it to the sea shore. There are other localities where the marl is situated, so that it can be readily shipped on board vessels, and numerous places situated in the interior, from which the best of marls could be cheaply procured if there were convenient means of transport.

The diminution in the cost of this article by the substitution of railroad transportation, for the conveyance by teams, will be understood when it is mentioned that formerly when marl was hauled from Squankum to Jamesburg, the cost at the latter place was thirteen cents a bushel. Now, parties interested propose if the railroad is extended from

*For these returns I am indebted to I. S. Buckalew, Esq., Superintendent of the Jamesburg and Freehold Agricultural Railroad.

Freehold to Squankum to deliver the marl in Belvidere that price.

Inquiries are being made in reference to the price of ma and its probable amount, by enterprising persons in oth states and in Europe. In regard to its price, it may mentioned that the Squankum marl sells at Freehold f eight cents a bushel,* and that the New Jersey Fertiliz Company deliver their marl on board vessels at their wha for seven cents a bushel. The White Horse marl is de livered on the line of the railroad at any point within te miles of the pits, at ninety cents a ton. At pits in differen parts of the marl region, the marl is sold at prices varyin with the labor of excavating, without much regard to it real worth. From twenty-five to seventy-five cents a ton includes the general range of prices.

The absolute worth of the marl to farmers, it is difficul to estimate. The region of country in which it is found ha been almost made by it. Before its use the soil was ex hausted, and much of the land had so lessened in value tha its price was but little, if any, more than that of govern ment lands at the west; while now, by the use of the marl these worn out soils have been brought to more than thei native fertility, and the value of the land increased fron fifty to a hundred fold. In these districts, as a genera fact, the marl has been obtained at little more than the cos of digging and hauling but a short distance. There ar instances, however, in which large districts, of worn ou land, have been entirely renovated by the use of this sub stance, though situated from five to fifteen miles from th marl beds, and when, if a fair allowance is made for labor the cost per bushel could not have been less than fron twelve to sixteen cents. Instances are known where it ha been thought remunerative at twenty-five cents a bushel.

The chemical composition of the marls may aid in esti mating their value, as fertilizers; though it must be con fessed that agriculturists are by no means agreed upon th

*A bushel weighs about 100 pounds when first dug, and about 80 pounds whe dry.

specific values which should be allowed for the different proximate elements found in manures.

The following are analyses of green sand marls, from different parts of the formation, and are selected as representatives of the principal varieties.*

	(1.)	(2.)	(3.)
Water	12.200	10.260	10.600
Silica	38.700	46.060	41.162
Prot-oxid of iron and alumina	27.690	24.921	22.300
Potash	4.467	6.81[illegible]	4.274
Lime	.....	2.865	3.478
Carbonate of lime	13.910	.....	.....
Magnesia	1.213	3.089	2.037
Phosphoric acid	1.140	3.599	4.540
Sulphuric acid	0.309	0.982	0.429
	99.629	99.194	98.820

These specimens are taken from the three principal marl beds; one from the first, two from the second, and three from the third. (1) is the marl which has been most largely used upon potatoes in Monmouth. (2) is the variety of marl which is most generally used in Burlington, Camden, Gloucester and Salem counties. (3) is the marl which is found in Deal, Poplar, Shark river, and Squankum, in Monmouth county.

In regard to the several constituents of the marl, it has been common to consider the phosphoric acid, and the potash, as the only substances of sufficient value to be taken into the account. Professor S. W. Johnson, of Yale College, in an article in the American Agriculturist for July, 1856, estimated the value of potash for agricultural purposes at four cents a pound, which is probably as close an approximation to its value as can be assigned, in the varying circumstances under which it is used in agriculture. Phosphoric acid he estimates at two different values, according as it is in a soluble or insoluble state. In its soluble form it is found in superphosphate of lime; in its insoluble form, in bones; to some extent, in superphosphate of lime and in guano. Soluble phosphoric acid he estimates at five

*For a description of the several beds of green sand, and their geological and geographical positions, see Geological Reports of New Jersey for 1854 and 1855.

cents a pound, and insoluble at two cents. Professor Way, Chemist of the Royal Agricultural Society of England, has estimated the worth of soluble phosphoric acid at eight and a half cents a pound, and insoluble at three cents. The prices of bones and of superphosphate are not very different in the two countries, and yet one of the results arrived at is more than fifty per cent. higher than the other. Such discordant results show the difficulties attending the subject for the authorities are, both men distinguished for care and accuracy in their investigations. If the estimate is to be made from the selling price of bone dust and superphosphate of lime, the prices assigned by Professor Way are not too high. There has been hardly time, since the first introduction of superphosphate of lime into our country, to ascertain the estimation in which it will be held by farmers. From the best information I have been able to procure, the amount of superphosphate annually manufactured is increasing. The price has diminished slightly within two or three years past, but it is still as high as the English. Bones, bone dust and bone turnings are increasing in price, and are more highly valued by the farmer every year. A reason for the differences in the value attached to phosphoric acid may probably be found, in the fact that its effects as a fertilizer, are much more perceptible upon some crops than upon others. Wheat, rye, and oats are known to be but little benefitted by it; while, on the contrary, its effects upon pastures, root crops, and garden vegetables, are entirely satisfactory. According, then, as one or other of these crops is the leading one with the farmer, will the phosphoric acid be esteemed. From the peculiar location of our state in relation to markets, and the nature of our leading products, I am led to the opinion that the prices fixed by Prof. Way are the nearest correct, for our uses. In the case of marl, however, even this is too low an estimate for the phosphoric acid. The acid is in its insoluble form; but it is disseminated through the marl in small particles, which are in a pulverulent state,—just as the superphosphate must be, as soon as it is washed into the soil,—which is a form much more availa-

ble for growing vegetation, than the hard and slow-decaying fragments of bones which have been crushed in a mill.

It is a safe estimate, at least, to rate the phosphoric acid in the marls at five cents a pound, the price assigned by Prof. Johnson for the soluble acid, and in relation to the potash, I think it should be put still higher.

As the analyses may be considered to give the absolute weights of each of the different constituents in one hundred pounds of marl,—its value will be easily calculated, by multiplying the numbers in the table by twenty, and then by the price mentioned above. Thus in (1) the potash, 4.467 ⋈ 20 = 89.34 and 4 ⋈ 89.34 = $3.57: the phosphoric acid 1.14 ⋈ 20 = 22.8 and 22.8 ⋈ 5 = $1.14: and the sum of the two is $4.71; the value of one ton of the marl, according to the above prices. In the same way (2) is worth $9.05, and (3) $7.96 a ton.

There are, however, other constituents which are of importance. Ammonia, which is acknowledged to be the most costly of all the fertilizing substances applied to soils, and which is indispensible to thrifty vegetation, is found, in small quantity, in all the marls.

The sulphuric acid, set down in the analysis, is usually combined with lime, and is in the form of sulphate of lime or plaster, a valuable fertilizer. In some of the marls there is a considerable quantity of carbonate of lime, in fine powder. This is also an excellent manure.

The oxid of iron and alumina, in their action, are not well understood. It has been asserted by some chemists that the protoxid of iron, in the marl, is changed to a peroxid by the action of air and moisture, and in the change ammonia is generated. That oxid of iron is an absorbent of ammonia is generally believed. In my report of last year I called attention to the fact that in the products of a given measure of land, a very much larger quantity of oxid of iron was taken up by potatoes than by any other commonly cultivated crop; and that this fact taken in connection with that of the large quantity of oxid of iron in marl, which is specially

adapted to the growth of this crop, appeared to have some significance. I hope to investigate the subject further.

Soluble silica which is liberated in large quantity, in the decomposition of these marls, has been rated very highly by some agricultural chemists.

The substances above mentioned are certainly found in large quantity, in common earths and soils, but they are not usually found in a condition to be easily made available to vegetation. The marls are soft so as to be readily penetrated by water, and though not soluble in pure water, they are readily decomposed by water containing acids, and are then soluble. Even carbonic acid, one of the weakest of acids, and which is found in water in the soil, is sufficient to decompose them, and to bring the various constituents into the condition necessary that they may act upon growing plants. It is believed that the other constituents of the marl which have not at all entered into the estimate of its value, increase its fertilizing power, both by direct action, and by their agency in absorbing and retaining other important elements of vegetable nutrition; but the precise value which is to be attached to them is not well understood.

The amount of the green sand marl which can be obtained for use is very great. It underlies the whole country in a strip which extends from Sandy Hook Bay and the Atlantic ocean, on the shore of Monmouth county, to Delaware river and bay, at Salem, in Salem county, a distance of ninety miles, and which has a breadth varying from fourteen miles at its northeastern extremity to six miles at its southwestern extremity. The area included in the strip is nine hundred square miles. On account of the marl being found in earth and not in rock, it cannot be worked under the surface like a mine; and excavations are profitably made in it only where the covering of top earth is but a few feet in thickness. In the greater portion of the area mentioned, the marl lies too deep under the surface to be profitably worked at present. But wherever streams have cut down below the general level of the country, some one of the different beds of marl is exposed, and on the sloping sides of the valleys, the deposit

lying nearly level, can be worked back for a considerable distance before the covering of earth becomes so thick as to render further progress unprofitable. Precise estimates have not yet been made of the amount of surface under which marl can be profitably worked, but there are certainly many square miles, even of those varieties which are generally considered the best.

In many cases a ton or more of marl is dug from underneath each square foot of surface; but, if we allow even half of this, for the amount obtained from each square foot, a square mile will yield (13,939,200) nearly fourteen million tons; an amount sufficient to supply any probable demand for years to come.

The calcareous marl which constitutes the upper part of the second marl bed, and which has been vairously designated, as yellow limestone, yellow marl, gray marl, lime, sand, etc., is extensively developed through the length of the marl district. It consists mainly of carbonate of lime. Some portions of it are pulverulent and can be worked with a shovel, while other portions are stony and can be used for burning into lime. Its value as a fertilizer is too well known to need description here.

The tertiary marls of Cumberland county are valuable as a source of manure for the district of country in which they lie. They are found on the western borders of the county and are principally dug in the valleys of several streams, which, when united form Stoe creek. The whole of the workings are comprised within a strip which extends about four miles in a northeast and southwest direction, and which is perhaps a half mile wide.

These marls are not green sand. Some of them have a large per centage of shells which are in a broken and decayed condition; others are entirely destitute of shells or of carbonate of lime. The two analyses which follow, are sufficient to exhibit their composition.

TABLE.

Silica and quartz sand, -	79.160	83.328
Peroxid of iron, - -	3.562	4.770
Alumina, - - - -	.442	5.412
Lime, - - - - -	7.500	0.211
Magnesia, - - - -	0.884	0.668
Potash, - - - -	1.227	0.829
Phosphoric acid, - -	0.420	0.854
Sulphuric acid, - - -	0.166	0.283
Carbonic acid, - - -	4.030	
Nitric acid, - - -		a trace
Ammonia, - - - -		0.067
Organic matter, - - -		1.967
Water, - - - -	2.400	2.193
	99.791	100.582

The first of these marls is like most of those containing shells, in some however fifty per cent. Some have attributed their value to the carbonate of lime in the shells; but those who use them do not consider this to be the cause of their fertilizing action, and make no difference in the price of those which contain shells and those in which there are none. There is a tract of country about Shiloh, upon which lime has never been observed to produce any beneficial effect; but which has been brought to a high degree of fertility by the use of these marls. They are carted to distances of five miles, and are thought to pay well for the expense of transportation, and the first cost, which is from fifty to seventy-five cents a wagon load.

The second analysis is that of a rather remarkable substance. It is called marl by the inhabitants, and is dug in the same tract of country with the other. To an ordinary observer it would seem to be a yellow loam or subsoil, and there is nothing by which a closer inspection would be able to distinguish any difference. It is extensively used as a manure, and is particularly valued for spreading upon grass

lands. Farmers purchase it at the pits for twenty-five cents a load, and haul it four or five miles for use, and think it well repays its cost.

The king-crabs or horse-feet, were mentioned in the Annual Report of last year, as abounding on some of our shores; and it was also mentioned that an establishment for making a concentrated manure, from them, had been erected at Goshen, in Cape May county, by Messrs. Ingham & Beesley. Several hundred tons of this substance were made last year and sold under the name of *Cancerine*. It is a powerful fertilizer, and in its composition as well as in its effects, has considerable resemblance to guano. The fertilizing properties of guano are generally conceded to be due to the amounts of ammonia and phosphoric acid which it contains. The per centages of ammonia and phosphoric acid contained in guano and in the cancerine, are here given.

	Ammonia.	Phosphuric Acid.
1. Peruvian Guano, - -	15.00	14.75
2. Peruvian Guano, - -	14.79	10.15
3. Cancerine, - - -	10.75	2·71
4. Cancerine, - - -	9.92	4.05

No. 1. is from an analysis of No. 1 Peruvian Guano, by Prof. S. W. Johnson, of Yale College; published in the American Agriculturist, for December, 1856.

No. 2. is from an analysis made in my laboratory. The specimen was obtained from a respectable dealer, in New Brunswick.

No. 3. is the result of an analysis of what I thought to be an average sample of Cancerine.

No. 4. is the average of three analyses of Cancerine, made here at different times.

In the article of Professor Johnson, which was just referred to, he estimates the value of ammonia at sixteen cents a pound, and phosphoric acid in guano, at two cents a pound; this would give the prices of

1. Guano, - - - -	$53.90 per ton.
2. Guano, - - - -	51.39 "
3. Cancerine, - - -	35.48 "
4. Cancerine, - - -	31.16 "

In this estimate phosphoric acid is set down at a lower price than I have assigned to it in calculating the value of green sand, but as the two prices bring the guano up to its selling price, and the only object is a comparison, this variation will not materially influence the relative values of the two.

There is a difference in the state in which the ammonia exists in the two substances. In guano much of it is ready formed, and is easily dissolved by water, or volatilized by heat; while in cancerine, though the elements are present, the ammonia is not yet formed, and it is not soluble nor volatile; and so not liable to deteriorate in strength, until the process of decay commences in it. But for the same reasons the guano is quicker in its action.

The result of trials with it, during the year, have fully sustained its value as determined by the analysis. The wheat crop of southern New Jersey, last year, was from five to ten bushels an acre less than common, probably on account of the severe winter. The effects of neither guano nor cancerine were very decided upon this crop. Some very good crops of wheat were harvested where cancerine was the only manure used. Upon summer crops, Indian corn, potatoes, &c., it has succeeded in all cases.

From the results obtained, I consider this pioneer establishment to have demonstrated that we have both the material and the means for manufacturing a concentrated manure which in its quality and price is a substitute for Peruvian guano. Several thousand tons of the cancerine could be produced in a year.

The fish, particularly the mossbonkers which abound near our shores, have been much used as a manure. Applied in the raw state, they are powerful fertilizers. An examina-

tion and analysis of the mossbonker has been made h the present fall, for the purpose of ascertaining the valu this fish, when dried, for manure.

ANALYSIS OF THE FRESH FISH.

Water,	77.17 per c
Oil,	3.90 "
Dry substance,	19.93 "
	100.00

Analysis of the dry Fish.

Lime,	8.670
Magnesia,	.670
Potash,	1.545
Soda,	1.019
Phosphoric acid,	7.784
Chlorine,	.678
Silica,	1.333
Organic matter,	78.301
	100.000
Ammonia,	9.282

There were five fishes in the lot examined, and weighed four pounds, four and one-eighth ounces, which little more than the average weight of such fish during spring and summer. They were taken in the latter pa October, and were quite fat.* The yield of oil from is probably above that of other seasons of the year. amounts of ammonia and phosphoric acid contained in dry fish are sufficient to make it a valuable concentı manure.

The amount of material for such manure which coul obtained upon our shores, has not been accurately estim

* The specimens were procured for me by Charles Sears, Esq., of Ri Monmouth county.

but it is enormous. A friend who has been at some pains in making inquiries upon the subject, estimates the amount which could be obtained at a single point on the shore, during one season, at one hundred thousand barrels. Sixty wagon loads were taken at a single haul, on the shore of Raritan Bay, the last summer. In different seasons the prices vary, between five and eight cents a bushel. The price on the shore of Monmouth county has not been below eight cents a bushel during the past season.

It would be a public benefit to have these supplies of fertilizing materials, which fairly bring themselves to our shores, put in a form to be more extensively used; and the oil and the fish manure offer fair opportunities for profit to a well conducted manufactory of these articles.

The following analyses of green sand marl were made from specimens taken from different parts of the marl formation for the purpose of comparing the composition of the green mineral. (1 and 2) are from the first marl bed, (1) from Mannington township, Salem county; (2) from Middletown, Monmouth county; (3 and 4) are from the second marl bed, (3) from Manningten, Salem county, and (4) from Shrewsbury, Monmouth, (5 and 6) are from the third or upper marl bed, (5) from Glouccster township, Camden county, and (6) from Ocean township, Monmouth county.

Analyses of Green Sand as taken from the Marl Beds.

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Peroxid of iron	8.020	10.856	21.412	21.201	14.959	17.9[illegible]
Alumina	6.096	6.658	7.992	8.230	6.000	6.048
Lime	2.364	12.524	1.040	0.496	1.985	4.168
Magnesia	0.423	2.511	2.034	2.024	1.515	2.563
Potash	2.464	4.880	7.091	7.088	4.286	5.830
Soluble silica	20.240	31.240	45.912	46.936	33.940	35.[illegible]
Insoluble silica	49.920	5.640	4.088	4.220	23.680	9.[illegible]
Sulphuric acid	0.572	0.632	0.408	.421	0.878	3.121
Phosphoric acid	1.392	1.084	1.272	0.192	2.641	0.804
Carbonic acid	0.240	9.520	.000	.000	.000	.[illegible]
Nitrogen	0.047	0.043	Trace.	0.017	0.048	0.021
Water	7.080	8.920	8.040	8.000	19.640	10.[illegible]
	99.378	100.261	99.092	99.418	100.662	99.05[illegible]

The per centage of matter soluble in water was ascertained to be as follows:

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Alumina	0.105	0.135	0.075	0.065	0.075	0.055
Lime	0.546	0.455	0.349	0.186	0.382	1.226
Magnesia	0.097	0.079	0.093	0.093	0.079	0.044
Potash	0.238	0.278	0.186	0.362	0.134	0.097
Sulphuric acid	0.876	0.415	0.398	0.406	0.813	2.876
Prot-oxid of iron	Trace.	Trace.	0.031	0.031	0.103	0.201
Phosphoric acid	.....	.....	.....	.....	0.365	0.194
	1.862	1.362	1.132	1.143	1.941	4.693

It should be observed in relation to these specimens of green sand, that they were not selected for the purpose of getting specimens of the average value as fertilizers, numbers 3 and 4 are much below the average, and number 6 is above, containing a larger per centage of phosphoric acid than any othhr specimen that I have examined.

The following analyses are of clean grains of green sand. The specimens were prepared by first washing out all clay and muddy substances that could be kept suspended in water; then drying the remaining matter at about a summer heat; and afterwards carefully picking out the grains of green sand from the particles of quartz, phosphate of lime and other substances with which they were mixed. After all the trouble taken, however, it will be perceived that there was a small quantity of sand and phosphate of lime left with the grains. The phosphate of lime is evidently not a constituent of the grains of green sand; it can be plainly distinguished from them in the mass, by the color of its particles, which are of a very light green or greenish white; but some of it adheres so closely to the green sand grains, as not to be separated by washing.

Of the three specimens here given; (1) is from the first marl bed, and was obtained at Cream Ridge, Monmouth county: (2) is from the second marl bed, and was procured at White Horse, Camden county; (3) is from the third marl bed, and was taken from a pile of Squankum marl, at Freehold.

Analyses of Grains of Green Sand.

	(1.)	(2.)	(3.)
Soluble silica	45.510	50.010	41.729
Prot-oxid of iron	21.134	21.120	16.627
Alumina	7.960	7.568	5.922
Magnesia	2.469	2.866	2.958
Potash	6.748	7.370	6.006
Lime	3.842	0.512	8.625
Phosphoric acid	0.993	0.625	7.356
Sulphuric acid	1.129	0.430?	1.046
Carbonic acid	0.533	0.000	1.343
Insoluble silica (sand.)	0.850	0.422	0.809
Water	9.110	9.474	7.699
	100.299	99.980	99.635

An examination of the preceding analyses will show that the soluble silica, prot-oxid of iron, alumina, magnesia, potash and water, are nearly the same, in quantity, in all the specimens, while the other constituents are extremely variable. It seems a legitimate conclusion from this examination, that the grains of green sand are made up of the constituents mentioned above, as being constant; and that the remainder compose the material which is found mixed in with the grains, and, in some cases, adhering to them. If we assume this conclusion to be correct and sum up, in each column, the six substances mentioned, as constituting the green sand, we may by an easy calculation ascertain the amount of each of these substances in one hundred parts of the pure green sand. The following are the results of such a calculation upon each of the three analyses given last.

Composition of Green Sand, as Calculated from the preceding Analyses.

	(1.)	(2.)	(3.)
Silica	48.977	50.923	51.532
Prot-oxid of iron	22.744	21.504	20.553
Alumina	8.566	7.703	7.322
Magnesia	2.647	2.918	3.658
Potash	7.262	7.505	7.491
Water	9.804	9.647	9.494
	100.000	100.000	100.000

The close resemblance shown between the three specimens, when compared in this way, gives satisfactory evidence that the green sand is a definite chemical compound. The inference, too, seems a fair one, that the variation which is observed in the fertilizing properties of the marl or green

sand, is due to the foreign matter mixed in with the grains, and which varies with the localities.

A re-examination of the white clay of South Amboy shows it to contain zirconia. Qulitative analyses of the white clays of Woodbridge and Trenton detect the same substance in them also, and it is probably a constituent of all the clays of this formation. There is reason to believe that the white clay at Trenton is produced by the decomposition of the gneiss rock, which occurs there. Crystals of zircon are not uncommon in the rock at that place.

Analysis of a fire-clay from Whitehead's clay-bank, on Burt's Creek, near South Amboy, Middlesex county.

Soluble Silica, - - -	43.937
Insoluble Silica, - -	1.703
Alumina, - - - -	38.008
Zirconia, - - -	1.403
Peroxid of iron, - -	0.747
Magnesia, - - -	0.077
Lime, - - - -	0.413
Potash, - - - -	0.368
Water, - - -	13.863
	100.519

In closing the report it should be remarked that those scientific details which must give to the survey its accuracy and value, have been mostly omitted, not from under-estimating their importance, but because it is judged they will find their more appropriate place in the final reports.

The practical and economical relations of the survey are the main objects for which it was instituted, and to these this report has been chiefly confined. If I have succeeded in exhibiting the important relations they hold to the mate-

[A.]

Table showing the areas of the states of Connecticut, New York, New Jersey, Pennsylvania and Delaware, in 1850 *; also, the Live Stock and Principal Agricultural Productions of those states in* 1840 *and* 1850.

	Connecticut.		New York.		New Jersey.		Pennsylvania.		Delaware.	
Areas of the States in acres	4,00[illegible]360		30,0[illegible]0,000		4,656,370		29,343,630		1,206,800	
Acres of improved land	1,768,173		12,408,954		1,737,991		8,621,619		580,562	
Acres of land, in farms, unimproved	615,701		6,710,121		934,955		6,294,278		375,282	
Per centage of whole area in farms	79		63		59		51		70	
Value of farms per acre	$30 50		$20 09		$43 67		$27 33		$19 75	
	1840.	1850.	1840.	1850.	1840.	1850.	1840.	1850.	1840.	1850.
Horses and mules.....Number.	34,659	29,936	474,543	447,977	70,502	68,044	335,129	352,657	14,421	14,643
Neat cattle	278,669	212,675	1,911,244	1,877,539	230,202	211,265	1,172,065	1,153,946	51,883	51,211
Sheep	493,462	174,131	5,118,777	3,433,241	279,285	160,498	1,767,620	1,822,357	29,247	27,503
Swine	131,941	75,472	1,900,065	1,019,252	261,433	250,370	1,505,964	1,040,365	74,228	53,261
Wheat.....Bushels.	87,469	41,702	12,283,418	13,121,498	774,203	1,001,190	13,213,077	15,367,619	315,165	485,514
Rye	737,421	640,893	2,979,323	4,148,782	1,665,829	1,255,578	6,613,873	4,865,100	33,546	8,096
Oats	1,453,262	1,253,735	20,675,847	26,552,314	3,088,524	3,378,633	20,641,819	21,538,156	927,405	604,518
Indian corn	1,530,441	1,923,013	10,972,286	17,858,100	4,391,975	8,759,704	14,240,022	19,835,214	2,090,359	3,145,942
Irish and sweet potatoes	3,114,238	2,669,805	30,123,614	15,403,597	2,072,089	3,715,251	9,535,643	6,032,901	200,712	305,965
Barley	34,769	17,069	2,520,663	3,586,059	12,501	6,492	209,893	165,584	5,260	56
Buckwheat	303,043	223,297	2,297,843	3,183,935	855,117	878,931	2,113,742	2,193,692	11,299	8,615
Hay.....Tons.	426,704	515,131	3,127,047	3,728,797	354,861	435,950	1,311,643	1,842,970	22,483	30,450
Value of orchard products.....Dollars.	$296,232	$175,118	$1,701,933	$1,761,950	$464,006	$607,268	$618,179	$723,399	$28,211	$46,574
Value of market garden produce	.....	196,874	.....	912,047	.....	475,242	.....	688,714	.....	12,714
Tobacco.....Pounds.	.....	1,267,624	.....	83,180	.....	310	.....	912,651	.....	.....
Butter	.....	6,493,119	.....	79,766,094	.....	9,487,210	.....	39,878,418	.....	1,055,308
Cheese	.....	5,363,277	.....	49,741,413	.....	365,756	.....	2,505,034	.....	3,178

[B.]

Table showing the per centage of *Loss* or *Gain*, in several staple agricultural products, in the states of Connecticut, New York, New Jersey, Pennsylvania and Delaware, from 1840 to 1850; also, the *Product* per acre in each state, when its whole crop of 1850 is divided among the whole number of acres in the state. (The product of wheat, rye, oats, Indian corn, potatoes, barley and buckwheat, is given in bushels; that of hay in tons; and of orchard products in dollars.)

	Conn.			N. York.			N. Jersey.			Pennsyl'a.			Delaware.		
	Loss.	Gain.	Product.	Loss.	Gain.	Product.	Loss.	Gain.	Product.	Loss.	Gain.	Product.	Loss.	Gain.	Product.
Wheat	52	...	.014	...	7	.436	...	107	.344	...	16	.529	...	53	.398
Rye	19	...	.200	...	58	.137	24	....	.269	30	...	.165	76	...	.006
Oats	13	...	.472	...	29	.882	...	9	.725	...	4	.742	35	...	.446
Indian corn	...	29	.644	...	63	.593	...	101	1.881	...	39	.683	...	49	2.518
Potatoes	22	...	.896	49	...	.512	...	79	.802	37	...	.208	...	52	.225
Barley	44	...	.006	...	42	.118	48	....	.001	21	...	.006	98	...	.....
Buckwheat	25	...	.076	...	39	.106	...	3	.189	...	4	.075	24	...	.006
			2.238			2.784			4.211			2.408			3.397
Hay	...	21	.170	...	19	.124	...	30	.093	...	40	.063	...	34	.022
Orchard products	41	...	.055	....	4	.958	...	31	.130	...	17	.025	...	65	.054

[C.]

Table showing the number of bushels of potatoes raised in the several counties of New Jersey and Delaware, in 1840 and 1850.

NEW JERSEY.

COUNTIES.	1840.	1850.
Sussex	2[illegible]	[illegible]
Warren	[illegible]	[illegible]
Passaic	[illegible]	[illegible]
Bergen	[illegible]	[illegible]
Hunterdon	[illegible]	[illegible]
Somerset	[illegible]	[illegible]
Morris	[illegible]	[illegible]
Essex	[illegible]	[illegible]
Hudson	[illegible]	[illegible]
Mercer	[illegible]	[illegible]
Middlesex	[illegible]	[illegible]
Cape May	[illegible]	[illegible]
Cumberland	[illegible]	[illegible]
Atlantic	[illegible]	[illegible]
Ocean, formed from Monmouth, in 1850	.....	[illegible]
Monmouth	[illegible]	[illegible]
Burlington	[illegible]	[illegible]
Camden, formed from Gloucester, in 1844	.....	[illegible]
Gloucester	[illegible]	[illegible]
Salem	[illegible]	[illegible]

DELAWARE.

COUNTIES.	1840.	1850.
New Castle	[illegible]	[illegible]
Kent	[illegible]	[illegible]
Sussex	[illegible]	[illegible]

REPORT

ON THE

TOPOGRAPHICAL DEPARTMENT.

December 31st, 1856.

SIR:

I herewith transmit the report of the operation under my direction, connected with the Topographical Department of the State Survey, from the first of January to the thirty-first of December, eighteen hundred and fifty-six.

Your Ob't Serv't,

EGBERT L. VIELE,

State Topographical Engineer.

WM. KITCHELL, *State Geologist and Sup't.*

REPORT.

The close of the year 1855 found the Topographical Department of the State Survey in a condition of active progression. The survey of the county of Sussex had been completed, drawn, and an engraved copy was in process of execution. The survey of the county of Cape May had also been completed, drawn, and preparations made for engraving it. The survey of the counties of Warren, Morris, and Monmouth were nearly completed and good progress made in the surveys of Salem and Cumberland counties. The triangulation of a large part of the northern portion of the state had been accomplished.

All of the difficulties incident to the first stages of so important a public work had been surmounted, and a thorough organization of every department was completed on principles which insured a perfect degree of accuracy and efficiency.

Great unanimity prevailed throughout the state in favor of the survey. The press yielded its cordial support, and the Legislature endorsed it with an almost unanimous approval. Under circumstances so gratifying it was natural that those, to whose charge the work had been entrusted, should feel an increased enthusiasm in the prosecution of their labors and should endeavor to push them to a successful completion. Guided by these feelings, the organization of the Topograghical corps was maintained.

A plane-table party was continued in the county of Cumberland and a revisory party in the county of Cape May.

The draughtsmen and engravers were continued and their work urged forward as rapidly as could be done consistently with the required accuracy.

Preparations were made for taking the field at an early day in the coming season, in short, every effort was made to keep up the vitality of the survey, but our designs were suddenly checked by the unfortunate circumstance, that the money was not in the Treasury to meet the applications made by the Legislature for the continuance of the survey, however, with the small sum obtained, arrangements were made to go on with the work by paying some of the employees a portion of their salary, others agreeing to wait for theirs until the money should be in the Treasury. Under this arrangement, parties were organized and took the field as follows:

Triangulation party, June 1st, 1856. This party continued in the field until the 11th day of October, occupying the following stations, of each at which twenty observations were taken with the theodolite.

1. Springfield, Essex county, } These two points are used as base lines for the work of the secondary triangulation.
2. Boonton, Morris county, }
3. Mt. Hope, Morris county,
4. Morris Plains, "
5. Horse Hill, "
6. Whippany, "
7. Parsippany, (Ch.) "
8. " (west.) "
9. " (south) "
10. Denville Depot, "
11. " (north,) "
12. " (south.) "
13. Hybernia, "
14. Split Rock "
15. Green Pond, "

16. Kickout, Morris county.
17. Ball Hill I, " } Pompton Mts.
18. " II, " }
19. Bloomingdale, Passaic county.
20. Pompton Plains, Morris county.
21. Pompton, "
22. Pompton Hill, (Church,) Passaic county.
23. Beavertown, Morris County.
24. Hook Mt. I, "
25. Hook Mt. II, "
26. " III, or Pine Brook, Morris county.
27. Hanover Neck, "
28. Beeches' Hill, Passaic county.
29. Ramopo I, "
30. " II, "
31. Wind beam, "
32. Book Mt., "
33. Cnaus Mt., "
34. Bearfort, "
35. Makapin, "
36. Carpenters' Farm, Sussex county.
37. Paul's Corner, "
38. Wawayando Mt. I, "
39 " II, "
40. Twenty-eighth Mile stone, " } on state line.
41. Twenty-ninth " " }
42. Amity Pochuk, state of New York.
43. Mt. Eva, " "
44. Greenville, (Blue Mts.) "
45. Port Jarvis, "
46. Pennsylvania, (station in) Pennsylvania.
47. Carpenters' Point, Sussex county.
48. High Point, "
49. Caldwell, (Church,) Essex county.
50. " Mt., "
51. Fairfield, (Church,) "

The observations made on the above fifty-one stations were one thousand and twenty. Besides the work above

mentioned, signals were erected at different stations on the Ramapo, Ringwood, and Greenwood Lake Mts., nineteen in number.

County of Morris.—A plane-table party took the field in this county on the first day of June, and was withdrawn on the thirteenth of November. The party had gone into the field with the determination to finish the survey of the county during this season if it could possibly be done. The illness of its chief for fifteen days delayed the work somewhat, yet it was within a few days of its completion when the party was withdrawn. They had been retained in the field after the small sum allowed to them had been exhausted, with the hope that the means to pay them could be obtained until the county was finished, but the party was withdrawn, with deep reluctance, and not until they had become embarrassed for want of funds.

Monmouth County.—The plane-table party was organized and sent into the field on the eleventh day of June, and continued actively engaged until the seventh of November, when, for want of funds, it was withdrawn, within a short time of its completion. A friend of the survey, not a resident of the state, supplied the necessary funds to organize a party to return to this county and complete the survey. This was done and I am happy to say the survey is completed and the map drawn.

Cumberland County.—A party was organized and sent into the field on the first day of July, and was withdrawn on the tenth day of November with it finishing the county. The party could work in this county all winter if the necessary means could have been allowed it.

The summary of the work thus far accomplished is as follows:

County of Cape May.—Survey completed, map drawn, engraved and published.

County of Sussex.—Survey completed, map drawn and partly engraved.

County of Monmouth.—Survey completed and map drawn.

County of Morris.—Survey nearly completed, and map partly drawn, (could have been completed in about three weeks).

County of Warren.—More than half surveyed.

County of Salem.—Half surveyed.

County of Cumberland.—Half surveyed.

County of Hudson.—This county could have been completed in four weeks, with the aid (which had been offered) of the New York Harbor Commissioners' work.

The plane-table sheets of the field work which have been finished, are backed and bound, to be deposited in the office of the Secretary of State. Thus the matter stands, and it remains for the legislature to take such action as in their wisdom they shall think best. I can add nothing to what has been said in regard to the value of the survey to the state. Its importance is stamped upon its face. To myself it would be a source of inexpressible gratification to see the work completed, even at a personal sacrifice, and I trust that the work so well begun, may not be suffered to languish for want of the proper support.

EGBERT L. VIELE,
State Topographical Survey.

A

CATALOGUE OF PLANTS

GROWING WITHOUT CULTIVATION IN THE COUNTIES OF

MONMOUTH AND OCEAN,

NEW JERSEY,

ACCORDING TO THE NATURAL SYSTEM AS PRESENTED IN THE SECOND EDITION OF GRAY'S MANUAL OF BOTANY, PUBLISHED IN THE YEAR MDCCCLVI.

BY P. D. KNIESKERN, M. D.

TRENTON:
PRINTED AT THE "TRUE AMERICAN" OFFICE.
1857.

PREFACE.

This catalogue is intended to embrace all the Phenogamous Plants and Ferns, found growing without cultivation within the limits of the counties of Monmouth and Ocean, as found and examined by myself, within the last ten or twelve years.

There are doubtless many plants that may still be detected within our limits, not included in this catalogue, especially in the portion farthest from the coast, which has not been examined as thoroughly as the pine-barrens and the region bordering on the sea.

In this catalogue, plants found only in the county of Monmouth are designated by a capital M., those of Ocean county with an O, and when neither letter is used it may be understood that the plants are common to both counties.

SHARK RIVER, Monmouth Co., N. J.,
December, 1856.

CATALOGUE OF PLANTS.

SERIES I.

PHÆNOGAMOUS OR FLOWERING PLANTS.

CLASS I.—DICOTYLEDONOUS OR EXOGENOUS PLANTS.

SUBCLASS I.—ANGIOSPERMÆ.

DIVISION I.—POLYPETALOUS EXOGENOUS PLANTS.

ORDER I.—RANUNCULACEÆ. (CROWFOOT FAMILY.)

Clematis Virginiana, *Linn.* Banks of Squan and Shark Rivers; not common. Monmouth County.

Anemone Virginiana, *Linn.* New Egypt, Ocean County and Middletown, M. Extremely rare.

A. nemorosa, *Linn.* Copses and margin of woods, common.

Thalictrum anemonoides, *Michx.* Margin of woods not common.

T. Cornuti, *Linn.* Meadows and along streams, quite common.

Ranunculus aquatilis, *Linn.*

var. divaricatus, *Gray.* Squan and Shark rivers, rare.

R. Cymbalaria, *Pursh.* Head of Barnegat Bay, near Point Pleasant, near salt water, quite rare. O.

R. abortivus, *Linn.* Shady hill-sides and banks of streams, common.

R. sceleratus, *Linn.* Wet ditches and pools, near New Egypt, rare.

R. recurvatus, *Poir.* Shady hill-sides and banks of streams, rare.

R. fascicularis, *Muhl.* Meadow woods near Squan Village, open woods not far from the village of Freehold, M.
R. bulbosus, *Linn.* Toms River, O., rare.
R. acris, *Linn.* New Egypt, O., rare.
Aquilegia Canadensis, *Linn.* In woods near Squan, M., rare.

ORDER II.—MAGNOLIACEÆ. (MAGNOLIA FAMILY.)

Magnolia glauca, *Linn.* Swamps quite common.
Liriodendron Tulipifera, *Linn.* Found sparingly on upland.

ORDER V.—BERBERIDACEÆ. (BARBERRY FAMILY.)

Berberis vulgaris, *Linn.* Near Red Bank, M., not common.

ORDER VII.—CABOMBACEA. (WATER-SHIELD FAMILY.)

Brasenia peltata, *Pursh.* Near Barrsville, O., and Shark River, M., not common.

ORDER VIII.—NYMPHÆCEÆ. (WATER-LILY FAMILY.)

Nymphæa odorata, *Ait.* Ponds and stagnant pools common.
Nuphar advena, *Ait.* Still or stagnant water common.

ORDER IX.—SARRACENACEÆ. (PITCHER-PLANTS.)

Sarracenia purpurea, *Linn.* Peat-bogs, common.

ORDER X.—PAPAVERACEÆ. (PAPPY FAMILY.)

Argemone Mexicana, *Linn.* Waste places, not common.
Chelidonium majus, *Linn.* Waste grounds, near dwellings, rare.
Sanguinaria Canadensis, *Linn.* Banks of a small stream, New Egypt, O., very rare.

ORDER XII.—CRUCIFERÆ. (MUSTARD FAMILY.)

Nasturtium Armoracea, *Fries.* Banks of streams and damp soil, not rare.

Cardamine rhomboidea, *D. C.* Wet meadows and springs, rare.

C. rotundifolia, *Michx.* Cool shaded springs, Middletown, M., very rare.

Arabis lyrata, *Linn.* Shady places, not common.

Sinapis alba, *Linn.* Waste places, rare.

S. arvensis, *Linn.* Too common in cultivated fields.

S. nigra, *Linn.* Fields and waste places furnishes the mustard of our tables, common near dwellings.

Draba verna, *Linn.* Sandy waste places and fields, common.

Camelina sativa, *Grantz.* Flax-fields, not common.

Lepidium Virginicum, *Linn.* Road-sides and waste places, common.

Capsella Bursa-pastoris, *Moenck.* Waste places, common.

Cakile Americana, *Nutt.* Coast, common.

Raphanus Raphanistrum, *Linn.* A troublesome weed, M.

ORDER XV.—VIOLACEÆ. (Violet Family.)

Viola lanceolata, *Linn.* Damp soil, common.

V. primulaefolia, *Linn.* Damp soil, common.

V. blanda, *Willd.* Damp and shady places common.

V. cucullata, *Ait.* Low grounds, everywhere common.

var. palmata, *Gray.* In like situations, but less common.

V. sagittata, *Ait.* Dry fields and road-sides common.

V. pedata, *Linn.* Dry sandy or gravelly soil in open woods and road-sides, common.

V. pubescens, *Ait.* Open woods, M.

ORDER XVI.—CISTACEÆ. (Rock-rose Family.)

Helianthemum Canadense, *Michx.* Sandy or dry gravelly soil.

H. corymbosum, *Michx.* Sandy or barren soil near the coast, not as common as the last.

Hudsonia ericoides, *Linn.* Dry pine barrens, quite common.

H. tomentosa, *Nutt.* Dry sandy coast and occasionally several miles inland; common.

Lechea major, *Michx.* Barren sandy fields, common.

L. thymifolia, *Pursh.* Barren sandy fields one mile west of Good-Luck Meadows, near Toms River, O., rare.

L. minor, *Lam.* Dry open woods and road-sides very common.

ORDER XVII.—DROCERACEÆ. (SUNDEN FAMILY.)

Drosera rotundifolia, *Linn.* Peat-bogs, common.

D. longifolia, *Linn.* Peat-bogs, common.

D. filiformis, *Raf.* Peat-bogs or wet sandy soil, neglected roads. These three species are frequently found growing together within the space of a few feet.

ORDER XVIII.—PARNASSIACEÆ. (PARNASSIA FAMILY)

Parnassia Caroliniana, *Michx.* Near marl-banks, New Egypt, O., rare.

ORDER XIX.—HYPERICACEÆ. (ST. JOHN'S-WORT FAMILY.)

Ascyrum stans, *Michx.* Borders of thickets pine-barrens, common.

A. Crux-Andreæ, *Linn.* Hill-sides and thickets, common.

Hypericum prolificum, *Linn.* Swamps in pine barrens, Manchester, O., common.

var. densiflorum, *Gray.* With the above, O., common.

H. perforatum, *Linn.* Pastures and meadows, fortunately not common.

H. corymbosum, *Muhl.* Damp or shady places, not common.

H. angulosum, *Michx.* Wet pine-barrens, not common.

H. mutilum, *Linn.* Low grounds, common everywhere.

H. Canadense, *Linn.* Wet sandy places, common.

H. Sarothra, *Michx.* Both wet and dry sandy fields, common.

Elodea Virginica, *Nutt.* In sandy swamps, common.

ORDER XXI.—CARYOPHYLLACEÆ. (PINK FAMILY.)

SUBORDER I.—SILENEÆ. (The Proper Pink Family.)

Saponaria officinalis, *Linn.* Road-sides, common.

Vaccaria vulgaris, *Host.* Partially naturalized, rare.

Silene stellata, *Ait.* Banks of Shark River, M., rare.
S. Pennsylvanica, *Michx.* Sandy woods, not common.
S. antirrhina, *Linn.* Dry soil and barren sandy fields, rare.
Agrostemma Githago, *Linn.* Wheat-fields, too common.

SUBORDER II.—ALSINEÆ. (The Chickweed Family.)

Honkenya peploides, *Ehrh.* Sandy sea-beach not rare.
Alsine squarrosa, *Fenzl.* In white sand sea-coast, common.
Arenaria serpyllifolia, *Linn.* Sandy waste places, not rare.
Stellaria media, *Smith.* Fields and around houses, common.
Cerastium vulgatum, *Linn.* Grassy banks, not common.
C. viscosum, *Linn.* Grassy fields and copses, common.
C. nutans, *Raf.* Moist places, common.
Sagina procumbens, *Linn.* Damp or springy places, not common.

SUBORDER III.—ILLECEBREÆ. (The Knotwort Family.)

Spergularia rubia, *Pers.* Sandy soil near the coast, common.
var. marina, *Gray.* Seacoast, common.
Spergula arvensis, *Linn.* Grain fiields, common.
Anychia dichotoma, *Mich.* In dry and also moist soil, rare.

SUBORDER IV.—SCLERANTHEÆ. (The Knawel Family.)

Scleranthus annuus, *Linn.* Sandy waste places, not rare.

SUBORDER V.—MOLLUGINEÆ. (Indian Chickweed Family.)

Mollugo verticillata, *Linn.* Sandy river banks and cultivated grounds, in gardens, a troublesome weed, common.

ORDER XXII.—PORTULACEÆ. (PURSLANE FAMILY.)

Sesuvium portulacastrum, *Linn.* On the coast, rare.
Portulaca, *Linn.* Cultivated and waste grounds, common.
Claytonia Virginica, *Linn.* In shady copses near New Egypt, O.

ORDER XXIII.—MALVACEÆ. (Mallow Family.)

Althæ officinalis, *Linn.* Salt marshes, common.
Malva rotundifolia, *Linn.* Door-yards and waste places, common.
M. sylvestris, *Linn.* Way-sides, rather rare.
Sida spinosa, *Linn.* Waste places, near New Egypt, O.
Abutilon Avicennæ, *Gaert.* Waste places, common.
Kosteletzkya Virginica, *Pres.* Marshes on the coast, rather rare.
Hibiscus Moscheutos, *Linn.* Banks of rivers, not rare on the coast.
H. Trionum, *Linn.* Escaped from gardens, not common.

ORDER XXIV.—TILIACEÆ. (Linden Family.)

Tilia Americana, *Linn.* Banks of Squan River, rare.

ORDER XXVI.—LINACEÆ. (Flax Family.)

Linum Virginianum, *Linn.* Dry woods, not rare.

ORDER XXVIII.—OXALIDACEÆ. (Wood-Sorrel Family.)

Oxalis violacea, *Linn.* Near Squan and Shark rivers, M., rare.
O. stricta, *Linn.* Woods and fields, common.

ORDER XXVIII.—GERANIADEÆ. (Geranium Family.)

Geranium maculatum, *Linn.* Open woods and along fences, common.
G. Carolinianum. Barren soil and waste places, common.

ORDER XXIX.—BALSAMINACEÆ. (Balsam Family.)

Impatiens fulva, *Nutt* Shady moist places, common.
var. alba. Near Toms River, O., has white flowers, not common.

ORDER XXXII.—ANACARDIACEÆ. (CASHEN FAMILY.)

Rhus copallina, *Linn.* Neglected fields and road-sides, common.
R. venenata, D. C. Swamps, very poisonous. Too common.
R. Toxicodendron, *Linn.* Low meadows and thickets, common.

ORDER XXXIII.—VITACEÆ. (VINE FAMILY.)

Vitis Labrusca, *Linn.* Thickets, and along fences, common.
V. aestivalis, *Mich.* Thickets, common.
V. cordifolia, *Mich.* River banks and thickets, common.
Ampelopsis quinquefolia, *Mich.* Woods and along fences. In rich damp soil, common.

ORDER XXXIV.—RHAMNACEÆ. (BUCKTHORN FAMILY.)

Ceanothus Americanus, *Linn.* (New Jersey Tea.) Dry open woods, and borders of fields and copses, common.

ORDER XXXVI.—SAPINDACEÆ. (SOAPBERRY FAMILY.)

SUBORDER I.—STAPHYLEACEÆ. (The Bladdernut Family.)

Staphylea trifolia, *Linn.* Banks of Squan River, rare.

SUBORDER III.—ACERINEÆ. (The Maple Family.)

Acer rubrum, *Linn.* Swamps and wet woods, everywhere common.

ORDER XXXVII.—POLYGALACEÆ. (MILKWORT FAMILY.)

Polygala lutea, *Linn.* Low meadows, and sandy swamps, common.
P. sanguinea, *Linn.* Damp meadows, not rare.
P. fastigiata, *Nutt.* Pine barrens, O., not common.
P. cruciata, *Linn.* Margins of swamps, common.
P. verticillata, *Linn.* Dry soil, common.

P. ambigua, *Nutt.* Dry and damp fields, common.
P. polygama, *Walter.* Dry sandy soil, rare.

ORDER XXXVIII.—LEGUMINOSÆ. (PULSE FAMILY.)

SUBORDER I.—PAPILIONACEÆ. (The proper Pulse Family.)

Lupinus perennis, *Linn.* Sandy fields and woods, common.
Crotalaria sagittalis, *Linn.* Sandy soil, common.
Trifolium arvense, *Linn.* Barren dry sandy fields, common.
T. pratense, *Linn.* Cultivated for hay and pasture, common.
T. repens, *Linn.* Pastures, meadows, &c., common.
Medicago lupulina, *Linn.* Waste places and roadsides, rare.
Robinia Pseudacacia, *L.* Cultivated for its valuable timber.
Tephrosia Virginiana, *Pers.* Dry sandy soil, very common.
Desmodium nudiflorum, *D. C.* Dry woods, Middletown, M., rare.
D. rotundifolium, *D. C.* Dry sandy fields, O., rare.
D. lævigatum, *D. C.* Pines of Ocean County, not common.
D. Dillenii, *Darlington.* Open sandy woods, O., common.
D. paniculatum, *D. C.* Copses and borders of woods, common.
D. strictum, *D. C.* Pine woods and neglected fields, rare.
D. Canadense, *D. C.* Borders of woods, not rare.
D. ciliare, *D. C.* Dry hills and sandy fields, common.
D. marilandicum, *Boott.* Copses and open woods, common.
Lespedeza procumbens, *Michx.* Sandy soil, not rare.
L. repens, *Torr. & Gray.* Dry sand fields and open woods, common.
L. violacea, *Pers.* Varieties of this species are common.
L. hirta, *Ell.* Dry sandy barren fields and hill-sides, common.
L. capitata, *Michx.* Varieties of this species occur in dry sandy or gravely fields and hill-sides, common.
Stylosanthes elatior, *Swartz.* Dry sandy road-sides, rare.
Vicia sativa, *Linn.* Cultivated fields, common.
Phaseolus diversifolius, *Pers.* Sand-hills, sea-coast, rare.
P. helvolus, *Linn.* Sandy fields, common.
Apios tuberosa, *Moench.* Moist thickets, common.

Galactia glabella, *Michx.* Open pine barrens, O., common.
Clitoria mariana, *Linn.* High banks, Toms River, O., rare.
Baptisia tinctoria, *R. Brown.* Dry sandy soil, common.

SUBORDER II.—CÆSALPINIEÆ. (The Brasiletto Family.)

Cassia Marilandica, *Linn.* Alluvial soil, not common. The leaves are sometimes used for medicine. M.
C. Chamæcrista, *Linn.* Sandy fields, common.
C. nictitans, *Linn.* Sandy fields and road-sides, common.
Gleditrehia triacanthus, *Linn.* Cultivated for ornament.

ORDER XXXIX.—ROSACAÆ. (ROSE FAMILY.)

SUBORDER I.—AMYGDALEÆ.

Prunus Americana, *Marsh.* Banks of streams, not common, M.
P. maritima, *Wang.* Near sea-beach, sandy open woods, common.
P. serotina, *Ehrhart.* Upland, common.

SUBORDER II.—ROSACEÆ.

Spiraea opulifolia, *Linn.* Cultivated about dwellings, rare.
S. salicifolia, *Linn.* Wet grounds, common.
S. tomentosa, *Linn.* Wet meadows, not common.
Agrimonia Eupatoria, *Linn.* Borders of woods, rare.
Sanguisorba Canadensis, *Linn.* Wet meadows near Freehold, M., rare.
Geum strictum. *Ait.* Damp shady places, not common.
Potentilla Norvegica, *Linn.* Cultivated fields, not common.
P. Canadensis, *Linn.* Dry sandy fields and woods, common.
Fragaria Virginiana, *Ehrhart.* Fields and open woods, common.
F. vesca, *Linn.* Fields and woods, not common.
Rubus villosus, *Ait.* Borders of thickets, fields, &c., common.
R. Canadensis, *Linn.* Sandy fields, very troublesome, common.

R. hispidus, *Linn.* Low woods, not rare.
R. cuneifolius, *Pursh.* Sandy fields and woods, common.
Rosa Carolina, *Linn.* Swamps and low grounds, common.
R. lucida, *Ehrhart.* Dry soil and neglected fields, common.
R. rubiginosa, *Linn.* Thickets and road-sides, common.

SUBORDER III.—POMEÆ.

Crataegus coccinea, *Linn.* Thickets and old fields, not rare.
C. Crus-galli, *Linn.* Thickets, not rare.
C. parvifolia, *Ait.* Pine barrens, O., common.
Pyrus arbutifolia, *Linn.* Borders of swamps, not rare.
var. melanocarpa, *Gray.* Damp thickets, common.
Amelanchier Canadensis, *Torr. & Gray.* Thickets, common.

ORDER XLI.—MELASTOMACEÆ. (MELASTOMA FAMILY.)

Rhexia Viginica, *Linn.* Sandy swamps, common.
R. Mariana, *Linn.* Sandy swamps, O., rare.
Nesaea verticillata, *H. B. K.* Low swamps, common.

ORDER XLIII.—ONAGRACEÆ. (EVENING-PRIMROSE FAMILY.

SUBORDER I.—ONAGRACEÆ. Proper.

Epilobium angustifolium, *Linn.* (Great willow-herb,) not common.
E. coloratum, *Muhl.* Wet places, common.
Œnothera biennis, *Linn.* Dry fields, very common.
Œ. fruticosa, *Linn.* Open fields, not common.
Ludwigia alternifolia, *Linn.* Swamps and damp places, common.
L. palustris, *Ell.* Ditches, common.

SUBORDER II.—HALORAGEÆ. (The Water-Milfoil Family.)

Proserpinaca pectinaceæ, *Lam.* Sandy swamps, Manchester, O., common.
Myriophyllum ambiguum, *Nutt.* In water, M., rare.

ORDER XLV.—CACTACEÆ (CACTUS FAMILY.)

Opuntia vulgaris, *Mill.* Sandy fields, Point Pleasant, Toms River, O.

ORDER XLVIII.—CUCURBITACEÆ. (GOURD FAMILY.)

Sicyos angulatus, *Linn.* Waste shady places, not common.

ORDER XLIX.—CRASSULACEÆ. (ORPINE FAMILY.)

Sedum Telephium, *Linn.* Near dwellings, not rare.
Penthorum sedoides, *Linn.* Near Egypt, O., rare.

ORDER L.—SAXIFRAGACEÆ. (SAXIFRAGE FAMILY.)

SUBORDER—SAXIFRAGACEÆ.

Saxifraga Virginiensis, *Michx.* Dry banks, not common.
Heuchera Americana, *Linn.* Shady banks, O., rare.
Chrysosplenium Americanum, *Schweinitz.* Cool damp places, rare.

SUBORDER II.—ESCALLONJEÆ.

Itea Virginica, *Linn.* Swamps, near Manchester, O., not rare.

ORDER LI.—HAMAMELACEÆ. (WITCH-HAZEL FAMILY.)

Hamamelis Virginica, *Linn.* Swamps and damp woods, rare.
Liquidambar Styraciflua, *Linn.* In dry soil and swamps, common.

ORDER LII.—UMBELLIFERÆ. (PARSLEY FAMILY.)

Hydrocotyle Americana, *Linn.* Banks of Shark River, M., rare.
H. umbellata, *Linn.* Point Pleasant, O., rare.
Sanicula Marilandica, *Linn.* Meadow woods near Squan, not common.
Eryngium Virginianum, *Lam.* Toms River, O., Squan Village, rare.

Daucus carota, *Linn.* Cultivated fields, too common.
Pastinaca sativa, *Linn.* Fields, near dwellings, too common.
Archemora rigida, *D. C.* Sandy swamps, common.
Archangelica hirsuta, *Torr. & Gray.* Dry open woods, not rare.
Thaspium barbinode, *Nutt.* Shady banks, Prospertown, O., rare.
T. aureum, *Nutt.* Copses and shady banks, rare.
Zizia integerrima, *D. C.* Shady banks and open woods, rare.
Osmorrhiza brevistylis, *D. C.* Rich woods, Middletown, M, rare.
Discopleura capillacæ, *D. C.* Near salt water, not rare.

ORDER LIII.—ARALIACEÆ. (Ginseng Family.)

Aralia spinosa, *Linn.* Cultivated for ornament.
A. racemosa, *Linn.* Cultivated in gardens, not wild here.
A. hispida, *Michx.* Sandy pine barrens, rather rare.
A. nudicaulis, *Linn.* Shady thickets, not rare.

ORDER LIV.—CORNACEÆ. (Dogwood Family.)

Cornus florida, *Linn.* Copses and open woods, not rare.
C. stolonifera, *Michx.* Wet banks of streams, common.
Nyssa multiflora, *Wang.* (Pepperidge, Tupelo, Black or Sour Gum.) Rich, dry or wet soil, common.

Division II.—Monopetalous Exogenous Plants.

ORDER LV.—CAPRIFOLIACEÆ. (Honeysuckle Family.)

Triosteum perfoliatum, *Linn.* Borders of woods, rare.
Sambucus Canadensis, *Linn.* Rich soil, common.
Viburnum nudum, *Linn.* Sandy swamps, common.
V. dentatum, *Linn.* Wet places, common.

ORDER LVI.—RUBIACEÆ. (Madder Family.)

Suborder I.—Stellatæ.

Galium trifidum, *Linn.* Damp places, common.

G. triflorum, *Michx.* Rich wood-lands, common.
G. pilosum, *Ait.* Dry open woods, not rare.

SUBORDER II.—CINCHONÆ.

Diodia teres, *Walt.* Sandy fields and roadsides, common.
Cephalanthus occidentalis, *Linn.* Wet banks, common.
Mitchella repens, *Linn.* Dry and damp woods, common.
Oldenlandia cærulea, *Gray.* Near Shark River, M., rare.

ORDER LVIII.—DIPSACEÆ. (TEASEL FAMILY.)

Dipsacus sylvestris, *Mill.* Road-sides, rare.

ORDER LIX.—COMPOSITÆ. (COMPOSITE FAMILY.)

Vernonia Noveboracensis, *Willd.* Wet meadows, common.
Liatris spicata, *Willd.* Salt meadows, near Squan, M. and Point Pleasant, O., rare.
L. graminifolia, *Willd.*
Var. dubia, *Gray.* Damp pine-barrens, O., not rare.
Eupatorium purpureum, *Linn.* Low grounds, common.
E. album, *Linn.* Dry and sandy fields, not rare.
E. teucrifolia, *Willd.* Low grounds, common.
E. rotundifolium, *Linn.* Dry soil, common.
E. resinosum, *Torr.* Damp pine-barrens, near Manchester, O., rare.
E. perfoliatum, *Linn.* Low grounds, common.
E. aromaticum, *Linn.* Near Squan Village, M., rare.
Mikania scandens, *Linn.* Shady copses, wet places, rare.
Conoclinum cœlestinum, *D. C.* Rich soil, not common.
Tussilago farfara, *Linn.* Wet places, rare.
Sericocarpus solidagineus, *Nees.* Dry thickets, not rare.
S. conyzoides, *Nees.* Dry sandy places, common.
Aster spectabilis, *Ait.* Sandy soil, not rare.
A. concolor, *Linn.* Sandy places, common.
A. patens, *Ait.* Dry soil, common.
A. cordifolius, *Linn.* Woods, common.
A. nemoralis, *Ait.* Bogs, in barrens, not rare.

Solidago bicolor, *Linn.* Dry sandy open woods, c
S. virgata, *Michx.* Damp pine barrens, O., commc
S. sempervirens, *Linn.* Salt marshes, quite commc
S. linoides, *Solander.* Bogs, not common.
S. altissima, *Linn.* Along fences and borders of w
S. ulmifolia, *Muhl.* Low places, common.
S. odora, *Ait.* Dry sandy woods, very common.
S. nemoralis, *Ait.* Dry fields, common.
S. Canadensis, *Linn.* Borders of thickets and wo
mon.
S. serotina, *Ait.* Thickets and low grounds, comm
S. tenuifolia, *Pursh.*
Chrysopsis falcata, *Ell.* Near Toms River, in d
soil, rare.
C. mariana, *Nutt.* Dry, sandy or gravelly soil, co
Inula helenium, *Linn.* Road-sides, rare.
Pluchea camphorata, *D. C.* Salt marshes, common
Baccharis halimifolia, *Linn.* Not far from the sea,
Silphium perfoliatum, *Linn.*
Ambrosia trifida, *Linn.* Rich, damp soil, rare.
A. artemiscæfolia. Fields, too common, everywhe
Xanthium strumarium, *Linn.* Near dwellings, not
Var. echinatum, *Gray.* Near sea-coast, not rare.
Heliopsis lævis, *Pers.* Banks and copses, common.
Rudbeckia laciniata. Thickets and along fences,
mon.

B. connata, *Muhl.* Wet soil, common.
B. chrysanthemoides, *Michx.* Wet places and swamps, common.
Maruta cotula, *D. C.* Road-sides, very common.
Anthemis arvensis, *Linn.* Fields, not rare.
Achillea millefolium, *Linn.* Fields and roadsides, common.
Leucanthemum vulgare, *Lam.* Fields and meadows, too common.
Tanacetum vulgare, *Linn.* Near dwellings, cultivated.
Artemisia caudata, *Michx.* Sandy soil near the coast, common.
Gnaphalium polycephalum, *Michx.* Very common.
G. purpureum, *Linn.* Sandy soil, not rare.
G. uliginosum, *Linn.* Ditches and road-sides, common.
Antennaria margaritacea, *R. Brown.* Dry places near the coast, rare.
A. plantaginifolia, *Hooker.* Sterile soil and banks, common.
Filago Germanica, *Linn.* Dry, barren fields, rare.
Erechthites hieracifolia, *Raf.* Waste places, newly burned over, common.
Cirsium lanceolatum, *Scop.* Fields and road-sides, common.
C. altissimum, *Spreng.* Fields and copses, common.
C. horridulum, *Michx.* Meadows, both salt and fresh, not rare.
Lappa major, *Gaert.* Rich soil and waste places, common.
Chichorium intybus, *Linn.* Waste places and road-sides, rare.
Krigia Virginica, *Willd.* Dry waste places, common.
Cynthia Virginica, *Don.* Moist banks, rather rare.
Hieracium venosum, *Linn.* Dry pine-plains, common.
H. paniculatum, *Linn.* Open woods, common.
Taraxacum Densleonis, *Desf.* Road-sides, common.
Lactuca elongata, *Muhl.* Rich soil, not rare.
Sonchus oleraceus, *Linn.* Waste places, common.
S. arvensis, *Linn.* Fields, not common.

ORDER LX.—LOBELIACEÆ. (Lobelia Family.)

Lobelia cardinalis, *Linn.* Low grounds, common.

L. inflata, *Linn.* Dry or damp soil, common.
L. Nuttallii, *R. & Schultes.* Sandy swamps, common.

ORDER LXI.—CAMPANULACEÆ. (CAMPANULA FAMILY.)

Campanula aparinoides, *Pursh.* Bogs and wet meadows, rare.
Specularia perfoliata, *D. C.* Dry fields, common.

ORDER LXII.—ERICACEÆ. (HEATH FAMILY.)

SUBORDER II.—VACCINIEÆ. (WHORTLEBERRY FAMILY.)

Gaylussacia dumosa, *Torr. & Gray.* Sandy swamps, not very rare.
G. frondosa, *Torr. & Gray.*
G. resinosa, *Torr. & Gray.* Woods and swamps, common.
Vaccinium Oxycoccus, *Linn.* Peat bogs, very common.
V. stamineum, *Linn.* Dry woods, very rare.
V. Pennsylvanicum, *Lam.* Dry hills and woods, common.
V. corymbosum, *Linn.* Swamps, common.

SUBORDER II.—ERICINEÆ.

Arctostaphylos Uva-ursi, *Spreng.* Pine barrens, common, O.
Epigæa repens, *Linn.* Sandy woods, common.
Gaultheria procumbens, *Linn.* Dry and damp woods, common.
Leucothœ racemosa, *Gray.* Swamps, common.
Cassandra calyculata, *Don.* Bogs and swamps, common.
Andromeda mariana, *Linn.* Sandy places, common.
A. ligustrina, *Muhl.* Swamps, common.
Clethra alnifolia. Swamps and dry sandy soil, common.
Kalmia latifolia, *Linn.* Dry woods, common.
K. angustifolia, *Linn.* Damp places, swamps, common.
Azalea viscosa, *Linn.* Sandy swamps, very common.
A. nudiflora, *Linn.* Thickets, on hills, common.
Leiophyllum buxifolium, *Ell.* Sandy damp barrens, O., not rare.

SUBORDER III.—PYROLEÆ.

Pyrola rotundifolia, *Linn.* Damp or shady woods, common.
Chimaphila umbellata, *Nutt.* Dry woods, common.
C. maculata, *Pursh.* Dry woods, common with the last.

SUBORDER IV.—MONOTROPEÆ.

Monotropa uniflora, *Linn.* Shady woods, common.
M. Hypopitys, *Linn.* Less common than the last, woods.

ORDER LXIV.—AQUIFOLIACEÆ. (HOLLY FAMILY.)

Ilex opaca, *Ait.* Swamps and dry soil, common.
Nemopanthes Canadensis, *D. C.* Swamps, O., rare.

ORDER LXVI.—EBENACEÆ. (EBONY FAMILY.)

Diospyros Virginiana, *Linn.* Woods, common.

ORDER LXVIII.—PLANTAGINACEÆ. (PLANTAIN FAMILY.)

Plantago major, *Linn.* Near dwellings, common.
P. maritima, *Linn.* Salt marshes, not rare.
P. lanceolata, *Linn.* Dry fields, very common.
P. Virginica, *Linn.* Sandy soil, not rare.
P. pusilla, *Nutt.* Dry fields and road-sides, not rare.

ORDER LXIX.—PLUMBAGINACEÆ. (LEADWORT FAMILY.)

Statice Limonium, *Linn.* Salt marshes, not rare.

ORDER LXX.—PRIMULACEÆ. (PRIMROSE FAMILY.)

Trientalis Americana, *Pursh.* Damp shady places, not rare.
Lysimachia stricta, *Ait.* Low grounds, common.
L. quadrifolia, *Linn.* Sandy soil, common.

FAMILY.)

Utricularia purpurea, *Walter*. Ponds, floating, n
U. subulata, *Linn.* Sandy swamps, rare.
U. cornuta, *Michx.* Peat bogs, common.

ORDER LXXII.—BIGNONJACEÆ. (BIGNONI

Tecoma radicans, *Juss.* Cultivated, not rare.
Catalpa bignonioides, *Walt.* Cultivated, common.
Martynia proboscidea, *Glox.* Escaped from gard

ORDER LXXII.—OROBANCHACEÆ. (BR
FAMILY.)

Aphyllon uniflorum, *Torr. & Gray.* Thickets
woods, rare.

ORDER LXXIV.—SCROPHULARIACEÆ. (
FAMILY.)

Verbascum thapsus, *Linn.* Fields and road-sides,
V. blattaria, *Linn.* Waste places and fields, rathe
Linaria Canadensis, *Spreng.* Sandy soil, common
L. vulgaris, *Mill.* Road-sides, not rare.
Scrophularia nodosa, *Linn.* Along fences, rather

Veronica Americana, *Schro.* New Egypt, O., rare.
V. serpyllifolium, *Linn.* Fields and road-sides, not rare.
V. arvensis, *Linn.* Cultivated fields, rather common.
Gerardia purpurea, *Linn.* Damp places, common.
G. maritima, *Raf.* Salt marshes, not rare.
G. tenuifolia, *Vahl.* Dry soil, common.
G. quercifolia, *Pursh.* Dry woods, common.
G. pedicularis, *Linn.* Dry shady places, sandy plains, common.
Pedicularis Canadensis, *Linn.* Banks and copses, common.
Melampyrum Americanum, *Michx.* Open and shady woods, common.

ORDER LXXVI.—VERBENACEÆ. (Vervain Family.)

Verbena angustifolia, *Michx.* Dry soil, rare.
V. hastata, *Linn.* Damp soil, common.
V. urticifolia, *Linn.* Road-sides and waste places, common.
V. officinalis, *Linn.* Fields, waste places, very rare.
Phryma leptostachya, *Linn.* Rich copses, not rare.

ORDER LXXVII.—LABIATÆ. (Mint Family.)

Teucrium Canadense, *Linn.* Low grounds, rather rare.
Trichostema lineare, *Nutt.* Sandy fields and barrens, not rare.
Mentha viridis, *Linn.* Wet meadows, common.
M. piperita, *Linn.* Brooks and low grounds, common.
Lycopus Virginicus, *Linn.* Moist shady places, common.
L. Europæus, *Linn.* Damp shady places, common.
Pycnanthemum aristatum, *Michx.* Pine barrens, not rare, O.
Calamintha clinopodium, *Benth.* Open thickets, rather rare.
Hedeoma pulegioides, *Pers.* Road-sides, common.
Collinsonia Canadensis, *Linn.* Rich open woods, common.
Salvia lyrata, *Linn.* Open woods and fields, common.
Monarda didyma, *Linn.* Damp open woods, not common.
M. punctata, *Linn.* Dry sandy fields, not common.
Nepeta Cataria, *Linn.* Near dwellings, common.

N. glechoma, *Benth.* Waste grounds, near dwellings, rare.
Physostegia Virginiana, *Benth.* Wet banks of streams, rare.
Brunella vulgaris, *Linn.* Woods and fields, common.
Scutellaria integrifolia, *Linn.* Damp places, common.
S. lateriflora, *Linn.* Wet shady places, rare.
Marrubium vulgare, *Linn.* Waste places, common.
Galeopsis Ladamum, *Linn.* Near dwellings, rare.
Stachys palustris, *Linn.* Wet banks, not common.
Leonurus Cardiaca, *Linn.* Waste places, near dwellings, not rare.
Lamium amplexicaule, *Linn.* Cultivated ground, rare.

ORDER LXXVIII.—BORRAGINACEÆ. (Borage Family.)

Echium vulgare, *Linn.* Waste sandy fields, rare.
Lithospermum arvense, *Linn.* Sandy banks, rare.
Myosotis palustris, *With.* Wet places, not rare.
Phlox pilosa, *Linn.* Borders of woods, not common, O.
Pyxidanthera barbulata, *Michx.* Common, a beautiful plant.
Ipomoea pandurata, *Meyer.* Sandy fields, Prospertown, O., rare.
Convolvulus arvensis, *Linn.* Fields, near the coast, common.
Calystegia sepium, *R. Brown.* Near Squan Village, M., not rare.
Cuscuta Epitinum, *Weihe.* Flax fields, not common.
C. glomerata, *Choisy.* On compositaca, not rare.

ORDER LXXXII.—SOLANACEÆ. (Nightshade Family.)

Solanum Dulcamara, *Linn.* Around dwellings, not common.
S. nigrum, *Linn.* Cultivated fields near dwellings, not rare.
Physalis viscosa, *Linn.* Fields and road-sides, not rare.
Datura Stramonium, *Linn.* Waste places, common.

ORDER LXXXIII.—GENTIANACEÆ. (Gentian Family.)

Sabbatia lanciolata, *Torr. & Gray.* Pine barrens, O., common.

S. stellaris, *Pursh.* Salt marshes, common.
S. chloroides, *Pursh.* Salt marshes, not rare.
Gentiana Andrewsii, *Griseb.* Shark River, not rare.
G. saponaria, *Linn.* Shark River, rare.
G. angustifolia, *Michx.* Damp soil, very rare.
Bartonia tenella, *Muhl.* Moist open places, not rare.
Limnanthemum lacunosum, *Griseb.* Ponds, rare.

ORDER LXXXIV.—APOCYNACEÆ. (DOGBANE FAMILY.)

Apocynum androsaemifolium, *Linn.* Borders of sandy thickets, not rare.
A. cannabinum, *Linn.* River banks, common.

ORDER LXXXV.—ASCLEPIADACEÆ. (MILKWEED FAMILY.)

Asclepias Cornuti, *Decaiens.* Fields and roadsides, rather rare.
A. obtusifolia, *Michx.* Sandy woods and fields, not rare.
A. paupercula, *Michx.* Salt marshes, O., not common.
A. incarnata, *Linn.* Wet grounds, common.
A. tuberosa, *Linn.* Dry fields, common.

ORDER LXXXVI.—OLEACEÆ. (OLIVE FAMILY.)

Ligustrum vulgare, *Linn.* Roadsides, not common.
Fraxinus viridis, *Michx.* Near streams, not rare.

Division III.—APETALOUS EXOGENOUS PLANTS.

ORDER LXXXIX.—PHYTOLACCACEÆ. (POKEWEED FAMILY.)

Phytolacca decandra, *Linn.* New ground, common.

ORDER XC.—CHENOPODIACEÆ. (GOOSEFOOT FAMILY.)

Chenopodium album, *Linn.* Fields and gardens, very common.

C. ambrosioides, *Linn.* Waste places, common.
Var. anthelminticum, *Gray.* (Worm seed.) Waste places, common.
Blitum maritimum, *Nutt.* Salt marshes, rare, O.
Atriplex hastata, *Linn.* Salt marshes, O., not rare.
Salicornia herbacea, *Linn.* Salt marshes, common.
S. ambigua, *Michx.* Salt marshes, less common.
Salsola Kali, *Linn.* Sea shore, common.
Chenopodina maritima, *Moquin.* Salt marshes, not rare.

ORDER XCI—AMARANTACEÆ. (Amaranth Family.)

Amarantus hybridus, *Linn.* Waste places, common.
A. spinosus, *Linn.* Waste places and roadsides, rare.
Acnida cannabina, *Linn.* Salt marshes, not common.

ORDER XCII.—POLYGONACEÆ. (Buckwheat Family.)

Polygonum orientale, *Linn.* Waste places, rare.
P. Pennsylvanicum, *Linn.* Moist waste places, common.
P. Persicaria, *Linn.* Waste places, common.
P. Hydropiper, *Linn.* Damp waste places, common.
P. aviculare, *Linn.* Everywhere, common.
Varieties erectum and littorale. Common, the last near the coast.
P. articulatum, *Linn.* Dry sandy soil, common.
P. arifolium, *Linn.* Low grounds, common.
P. sagittatum, *Linn.* Low grounds common.
P. convolvulus, *Linn.* Waste places, common.
P. dumetorum, *Linn.* Thickets, not rare.
Fagopyrum esculentum, *Moench.* Cultivated fields, waste places.
Rumex verticillatus, *Linn.* Swamps, common.
R. obtusifolius, *Linn.* Fields, common.
R. crispus, *Linn.* Waste and cultivated grounds, common.
R. maritimus, *Linn.* Salt marshes, not rare.
R. acetosella, *Linn.* Fields and pastures, too common.

ORDER XCIII.—LAURACEÆ. (Laurel Family.)

Sassafras officinale, *Nees.* Dry gravelly hills, common.
Benzoin odoriferum, *Nees.* Swamps, rather common.

ORDER XCVI.—SANTALACEÆ. (Sandalwood Fam.)

Comandra umbellata, *Nutt.* Sandy open woods, not rare.

ORDER XCVII.—LORANTHACEÆ.

Phoradendron flavescens, *Nutt.* On Pepperidge trees, rare.

ORDER XCVIII.—SAURACEÆ. (Lizard's-Tail Fam.)

Saururus cernuus, *Linn.* Borders of ponds and streams, O., rare.

ORDER CII.—EUPHORBIACEÆ. (Spurge Family.)

Euphorbia polygonifolia, *Linn.* Sandy sea-shore, common.
E. hypericifolia, *Linn.* Fields and meadows, rather rare.
E. Ipecacuanhæ, *Linn.* Sandy soil, very common.
E. corrollata, *Linn.* Sandy soil, common.
Acalypha Virginica, *Linn.* Fields and open places, not rare.
A. gracilens, *Gray.* Sandy fields, quite common.
Crotonopsis lineare, *Michx.* Near Manchester, O., and Southwark, rare.

ORDER CIV.—URTICACEÆ. (Nettle Family.)

Suborder I.—Ulmaceæ.

Ulmus Americana, *Linn.* River banks, rather rare.
Celtis occidentalis, *Linn.* Banks of Tom's River, O., rare.

Suborder II.—Atrocarpeæ.

Morus rubra, *Linn.* Around dwellings, common.

SUBORDER IV.—CANNABINEÆ.

Humulus Lupulus, *Linn.*

ORDER CV.—PLATANACEÆ. (PLANE-TREE FAM.)

Platanus occidentalis, *Linn.* Banks of streams, common.

ORDER CVI.—JUGLANDACEÆ. (WALNUT FAMILY.)

Juglans cinerea, *Linn.* Rich soil; banks of streams, rare.
J. nigra, *Linn.* About dwellings and in fields, rare.
Carya tomentosa, *Nutt.* Rich woods, the common hickory.
C. amara, *Nutt.* Woods, common.

ORDER CVII.—CUPULIFERÆ. (OAK FAMILY.)

Quercus obtusiloba, *Michx.* Sandy soil, common.
Q. alba, *Linn.* Rich soil, very common and valuable.
Q. Prinus, *Linn.*
Var. monticola, *Michx.* Hilly woods, common.
Q. prinoides, *Willd.* Sandy soil, quite common.
Q. Phellos, *Linn.* Low sandy woods, rather rare.
Q. nigra, *Linn.* Dry sandy soil, common.
Q. ilicifolia, *Wang.* Pine-barrens, common.
Q. tinctoria, *Bartram.* Dry hills, not rare.
Q. falcata, *Michx.* Point Pleasant, rather rare.
Q. rubra, *Linn.* Hills and dry woods, common.
Castanea vesca, *Linn.* Dry sandy soil, not rare.
Fagus ferruginea, *Aiton.* Banks of Squan and Shark River, rare.
Corylus Americana, *Walt.* Thickets and river banks, common.
Carpinus Americanus, *Michx.* River banks, not rare.

ORDER CVIII.—MYRICACEÆ. (SWEET-GALE FAMILY.)

Myrica cerifera, *Linn.* Dry sandy soil, very common.
Comptonia asplenifolia, *Ait.* Dry sandy soil, very common.

ORDER CIX.—BETULACEÆ. (Birch Family.)

Betula alba var. populifolia, *Spach.* Poor soil, common.
B. nigra, *Linn.* River banks, common.
Alnus serrulata, *Ait.* River banks and swamps, common.

ORDER CX.—SALICACEÆ. (Willow Family.)

Salix nigra, *Marshall.* Damp borders of streams, common.
Several other species occur here but have not been examined at the proper time for determination.
Populus tremuloides, *Michx.* Woods, not rare.
P. balsamifera, *Linn.*
Var. candicans, *Gray.* (Balm of Gilead,) not rare.

Subclass II.—Gymnospermæ.

ORDER CXI.—CONIFERÆ. (Pine Family.)

Suborder I.—Abietineæ. (Proper Pine Family.)

Pinus inops, *Ait.* Sandy soil, very rare.
P. mitis, *Michx.* Dry sandy soil, common.
P. rigida, *Miller.* Dry and wet soil. The most common.
P. strobus, *Linn.* Dry and damp soil, rare.
Abies Canadensis. Shady borders of swamps, very rare.

Suborder II.—Cupressineæ.

Cupressus thyoides, *Linn.* Swamps, O., very common.
Juniperus Virginiana, *Linn.* Dry sandy soil, common.

Class II.—Monocotyledonous or Endogenous Plants.

ORDER CXII.—ARACEÆ. (Arum Family.)

Arisæma triphyllum, *Torr.* Shady ravines and river banks, rare.
Peltandra Virginica, *Raf.* Wet places and in water, not rare.

Symplocarpus fœtidus, *Salisb.* Wet places, common.
Orontium aquaticum, *Linn.* Swamps and in shallow streams, rare.
Acorus calamus, *Linn.* Borders of swamps, rather rare.

ORDER CXIII.—TYPHACEÆ. (Cat-tail Family.)

Typha latifolia, *Linn.* Deep swamps or ponds, not rare.
T. angustifolia, *Linn.* Borders of creeks near salt water, rare.
Sparganium simplex, *Hudson.* Shallow streams and pools, common.

ORDER CXIV.—NAIDACEÆ. (Pond-weed Family.)

Zostera marina, *Linn.* Barnegat bay, Squan and Shark River.
Ruppia maritima, *Linn.* Toms' River in four feet water, rare.
Potamogeton pauciflorus, *Pursh.* Slow running streams, not rare.
P. natans, *Linn.* Shallow water, not rare.

ORDER CXVI.—ALISMACEÆ. (Water-Plantain Family.)

Sagittaria varibilis, *Engelm.* Wet places, ponds, &c., common.

ORDER CXVII.—HYDROCHARIDACEÆ. (Frog's-bit Family.)

Limnobium Spongiosa, *Richard.* Swimming River, M., rare.
Valisneria spiralis, *Linn.* Slow rivers, not rare.

ORDER CXIX.—ORCHIDACEÆ. (Orchis Family.)

Gymnadenia tridentata, *Lindl.* Cold shady swamps, rare.
G. flava, *Lindl.* Wet places, not common.

Platanthera ciliaris, *Lindl.* Wet meadows, not common.
P. blephariglottis, *Lindl.* Swamps, common.
Spiranthes gracilis, *Bigelow.* Sandy plains, common.
S. cernua, *Richard.* Wet meadows, common.
Arethusa bulbosa, *Linn.* Cold bogs and cedar swamps, rare.
Pogonia ophioglossoides, *Nutt.* Swamps, not rare.
P. verticillata, *Nutt.* Damp shady places, not common.
Calopogon pulchellus, *R. Brown.* Bogs, common.
Liparis liliifolia, *Richard.* Near Manchester, O., rare.
Cypripedium acaule, *Ait.* Woods, common.

ORDER CXX.—AMARYLLIDACEÆ. (Amarillis Family.)

Hypoxys erecta, *Linn.* Dry woods and fields, common.

ORDER CXXI.—HÆMODORACEÆ. (Bloodwort Family.)

Lachnanthes tinctoria, *Ell.* Sandy swamps near Manchester, O., rare.
Lophiola aurea, *Ker.* Sandy swamps, O., not so rare.
Aletris farinosa, *Linn.* Dry or damp grassy places, common.

ORDER CXXIII.—IRIDACEÆ. (Iris Family.)

Iris versicolor, *Linn.* Wet places, common.
I. Virginica, *Linn.* Marshes near the coast, not so common.
Sisyrinchium Bermudiana, *Linn.* Dry and damp places, common.

ORDER CXXIV.—DIOSCOREACEÆ. (Yam Family.)

Dioscorea villosa, *Linn.* Swamps, not rare.

ORDER CXXV.—SMILACEÆ. (Smilax Family.)

Smilax rotundifolia, *Linn.* Dry woods and wet thickets, common.

S. tamnifolia, *Michx.* Open fields and shady places, not rare.
Medeola Virginica, *Linn.* Rich shady woods, rather rare.

ORDER CXXVI.—LILIACEÆ. (Lily Family.)

Asparagus officinalis, *Linn.* Waste places, not common.
Polygonatum biflorum, *Ell,* Along fences and waste places, not rare.
P. giganteum, *Dietrich.* Rich soil on river banks, common.
Smilacina racemosa, *Desf.* Shady copses, not rare.
S. trifolia, *Desf.* Shady places, very rare.
S. bifolia, *Ker.* Damp open woods, common.
Hemerocallis fulva, *Linn.* Cultivated or waste places, rare.
Ornithogalum umbellatum, *Linn.* Damp meadows, Squan., M.
Allium cernum, *Roth.* Fields, too common.
Lilium Philadelphicum, *Linn.* Open copses, not rare.
L. Canadense, *Linn.* Moist bogs and meadows, not common.
L. superbum, *Linn.* Rich low meadows, common, a fine species.
Erythronium Americanum, *Smith.* River banks, not rare.

ORDER CXXVII.—MELANTHACEÆ. (Colchicum Family.)

Suborder I.—Uvularieæ.

Uvularia sessilifolia, *Linn.* Damp shady places, not rare.

Suborder II.—Melanthieæ.

Melanthium Virginicum, *Linn.* Wet meadows, rather rare.
Zygadenus leimanthoides, *Gray.* Wet meadows, rather rare.
Veratrum viride, *Ait.* Low grounds, not common, M.
Xerophyllum asphodeloides, *Nutt.* Pine barrens, more common in O.
Helonias bullata, *Linn.* Swamps, very rare.
Tofieldia pubens, *Ait.* Near Manchester in a swamp, rare, O.

ORDER CXXVIII.—JUNCACEÆ. (Rush Family.)

Luzula campestris, *D. C.* Dry fields and woods, rather common.
Juncus effusus, *Linn.* Wet meadows, common.
J. maritimus, *Lam.* Brackish marshes, common.
J. scirpoides, *Lam.* Wet borders of streams, not rare.
J. militaris, *Bigelow.* Near Manchester, O., not common.
J. bulbosus, *Linn.* Salt meadows, quite common near the coast.
J. bufonius, *Linn.* Road-sides in wet places, common.

ORDER CXXIX.—PONTEDERIACEÆ. (Pickerel-weed Family.)

Pontederia cordata, *Linn.* Shallow water, not rare.
Tradescantia Virginica, *Linn.* Waste places, not common.

ORDER CXXXI.—XYRIDACEÆ. (Yellow-eyed Grass Family.)

Xyris Caroliniana, *Walt.* Sandy swamps, quite common.
X. fimbriata, *Ell.* Pine barrens near Manchester, O., rare.

ORDER CXXXII.—ERIOCAULONACEÆ. (Pipewort Family.)

Eriocaulon decangnlare, *Linn.* Pine barren swamps, common.
E. septangulare, *Withering,* Ponds or borders of them, not rare, O.

ORDER CXXXIII.—CYPERACEÆ. (Sedge Family.)

Cyperus flavescens, *Linn.* Low grounds, near Good-Luck Point, Ocean county, very rare.
C. diandrus, *Torr.* Low grounds, common.
Var. castaneus, *Torr.* With the former, common.
C. nuttallii, *Torr.* Common near salt or brackish water.

C. strigosus, *Linn.* Low and rich grounds, common.
C. dentatus, *Torr.* Sandy swamps, common near the coast.
C. Grayii, *Torr.* Barren sandy soil near the coast.
C. filiculmis, *Vahl.* Barren sandy soil, not rare.
C. ovularis, *Torr.* Sandy fields and road-sides, common.
Dulichium spathaceum, *Persoon.* Borders of ponds, swamps.
Eliocharis tuberculosa, *R. Brown.* Wet sandy places, not far from the sea-coast, common.
E. obtusa, *Schultes.* Muddy places, not common.
E. olivacea, *Torr.* Wet sandy places, common.
E. tenuis, *Schultes.* Swamps and wet places, common.
E. tricostata, *Torr.* Near Quaker-Bridge and Webb's old field, the northern limit of this plant, rare, O.
E. acicularis, *R. Brown.* Muddy borders of ponds, common.
Scirpus subterminalis, *Torr.* Slow running streams, rare, O.
S. pungens, *Vahl.* Borders of salt and fresh water, common.
S. Olneyi, *Gray.* Salt marshes Toms' River, O. and near Squan Village, M., rare.
S. lacustris, *Linn.* Fresh water ponds, common.
S. maritimus, *Linn.* Salt meadows, common.
S. Eriophorum, *Michx.* Wet meadows and swamps, common.
Eriophorum Virginicum, *Linn.* Bogs and wet places, common.
E. polystachyon, *Linn.* Peat-bogs, not common.
Fimbristylis spadicea, *Vahl.* Salt marshes, common.
F. autumnalis, *R. & Schultes.* Low grounds, common.
F. capillaris, *Gray.* Dry barren and sandy fields, common.
Fuirena squarrosa, *Michx.* Salt-marshes, Toms' River, O., rare.
Var. pumila, *Torr.* Near Shark River, M., rare.
Ceratoschoenus macrostachya, *Gray.* Beaverdam, Manchester, M., rare.
Rhynchospora cymosa, *Nutt.* Damp grounds near Newberry Pond, on Commodore Stockton's farm, Squan, M., rare.
R. Torreyana, *Gray.* Damp grounds and road-sides, O., rare.
R. fusca, *R. & Schultes.* Swamps near Manchester, O., abundant.
R. gracilenta, *Gray.* Low sandy swamps, common.

R. alba, *Vahl.* Cranberry bogs, common.

R. Knieskernii, *Carey.* Paint-Hollow, on bog-iron-ore beds, two miles from Manchester, O., on the road to Cassville, rare.

R. glomerata, *Vahl.* Low grounds, everywhere common.

R. cephalantha, *Torr.* Bogs near Manchester, O., very rare.

Cladium mariscoides, *Torr.* Bogs, common near the coast.

Scleria triglomerata, *Michx.* Low and rather dry soil, common.

S. laxa, *Torr.* Paint-Hollow, near Manchester, O.

S. pauciflora, *Muhl.* Near Shark River, M. Dry upland, rare.

Carex, exilis, *Dewey.* Low swamps Manchester and Burrsville, O. Near Shark River, M. Abundant in some localities.

C. vulpinoidea, *Michx.* Low meadows, common.

C. stipata, *Muhl.* Swamps and wet meadows, common.

C. cephalophora, *Muhl.* Meadow-woods near Squan Village, M., rare.

C. Muhlenbergii, *Schk.* Dry sandy fields, rare.

C. rosea, *Schk.* Meadow-woods near Squan Village, M., not common.

C. retroflexa, *Muhl.* Meadow-woods near Squan Village, M., rare.

C. trisperma, *Dewey.* Shady swamps near Manchester, very rare.

C. canescens, *Linn.* Marshes and wet meadows, common.

C. stellulata, *Good.* Wet meadows and marshes, common also.

Var. scirpoides, *Carey.* In similar localities, common.

Var. sterilis, *Carey.* Wet places, common.

Var. angustata, *Carey.* Marshes, common.

C. Scoparia, *Schk.* Low meadows and swamps, very common.

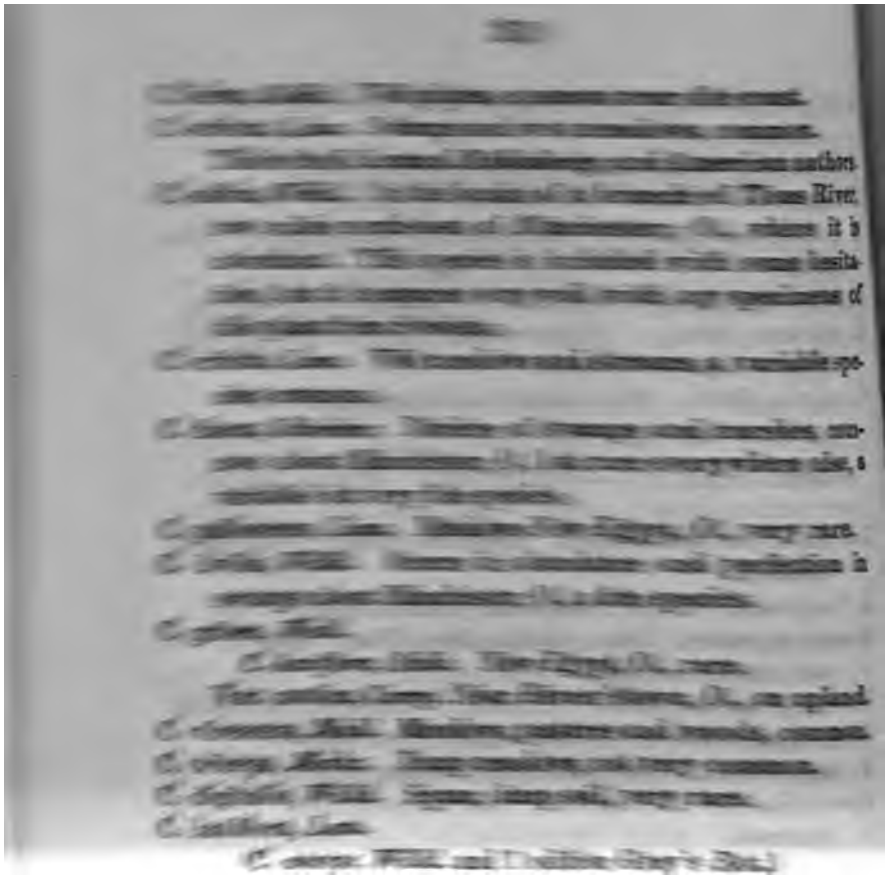
C. festucacea, *Schk.* Wet meadows, common.

Var. tenera, *Carey.* Wet meadows, not common.

Var. mirabilis, *Carey.* Damp meadows, rare.

C. straminea, *Schk.* Dry fields and along fences, rather rare.

Var. moniliformis, *Tuckermann.* Occurs on the coast, common.



C. pallescens Willd. Pale Sedge. Low grounds, common.

C. Pennsylvanica Lam. Dry open woods and hills, common.

C. laxiflora Muhl. Woods and meadows, common.

C. plantaginea Lam. Rich woods, rare.

C. varia Muhl. Var. *monilifera*. Moist woods and meadows, common.

C. virescens Muhl. Var. *costata*. Woods, rare.

C. Muhlenbergii Schk. Var. *enervis*. Dry woods, common.

C. Muhlenbergii Schk. Var. *Muhlenbergii*. Dry woods and hill-sides, especially near Zanesville, rare.

C. Pennsylvanica Lam. Dry open woods and hills, common.

C. lurida Muhl. Var. *monilifera*. Wet meadows and spring hillsides, common.

C. annectens Muhl. Wet meadows, near Squaw Village, Muskingum Co.

C. retrorsa Willd. Slightly damp fields and open woods, rare.

C. polymorpha Muhl. *C. Hallii* Dewey. Borders of swamps, rare.

C. striata, *Michx.* Wet places near Manchester, O., not common.
C. hystricina, *Willd.* Wet places, quite common.
C. tentaculata, *Muhl.* Wet meadows, common.
C. intumescens, *Rudge.* Swamps and wet meadows, common.
C. folliculata, *Linn.* Swamps and wet meadows, common.
C. subulata, *Michx.* Cedar-swamps and borders of small streams, quite common.
C. bullata, *Schk.* Wet meadows and swamps, not rare.

ORDER CXXXIV.—GRAMINEÆ. (Grass Family.)

Leersia dryzoides, *Swartz.* (Rice cut-grass.) Wet places, common.
L. Virginica, *Willd.* Damp shady places, not common.
Zizania aquatica, *Linn.* (Indian Rice, Water Oats.) Near salt water, common.
Phleum pratense, *Linn.* (Timothy.) Meadows, cultivated.
Vilfa aspera, *Beauv.* (Rush Grass.) Not common.
V. vaginæflora, *Torr.* Borders of woods, rare.
Sporobolus serotinus, *Gray.* (Drop-seed-grass.) Swamps, common.
Agrostis scabra, *Willd.* (Bent-grass.) Not common.
A. vulgaris, *With.* (Red-top.) Cultivated for hay and pasture.
A. alba, *Linn.* (White bent-grass.) Damp places, rare.
Cinna arundinacea, *Linn.* (Wood reed-grass.) Shady places, rare.
Muhlenbergia Mexicana, *Trinius.* Shady places, rare.
M. sylvatica, *Torr. & Gray.* Shady places, along fences, rare.
M. Willdenovii, *Trinius.* Shady places, not common.
M. diffusa, *Schreber.* Shady places, not common.
Brchyelytrum aristatum, *Beauv.* Shady banks, near Shark River, not common.
Calamagrostis Canadensis, *Beauv.* Low meadows near Squan and Shark Rivers, common, M.

C. coarctata, *Torr.* Damp and shady places, rare.
C. brevipilis, *Gray.* Moderately damp places, rare.
C. arenaria, *Roth.* Sandy beaches and sand-hills. Useful in binding drifting sands together, common.
Stipa avenacea, *Linn.* (Black Oat-grass.) Dry sandy or gravelly open woods, common.
Aristida dichotoma, *Michx.* Dry sandy fields and road-sides, common.
A. gracilis, *Ell.* Dry sandy woods and road-sides, common.
A. purpuracens, *Poir.* Sand fields and road-sides, not rare.
A. tuberculosa, *Nutt.* Sandy soil, Middletown, M., rare.
Spartina polystachya, *Willd., Muhl.* (Salt Reed-grass.) Salt or brackish marshes, within tide-water, common.
S. juncea, *Willd.* Damp sandy beaches and salt marshes, common.
S. glabra, *Muhl.* Salt marshes, common.
Eleusine Indica, *Gærtner.* Yards and cultivated grounds, common.
Tricuspis sesleroides, *Torr.* Dry shady places, rare.
T. purpurea, *Gray.* Dry white sand, not common.
Dactylis glomerata, *Linn.* (Orchard-grass.) Cultivated, rare.
Glyceria Canadensis, *Trin.* Bogs and wet places, not common.
G. obtusa, *Trin.* Wet meadows and swamps, rather common.
G. nervata, *Trin.* Wet meadows, common.
G. pallida, *Trin.* Sluggish, shallow streams, not rare.
G. fluitans, *R. Brown.* Wet places, not common.
Brizopyrum spicatum, *Hooker.* Salt meadows, common.
Poa annua, *Linn.* Door-yards. Introduced, common.
P. alsodes, *Gray.* *P. nemoralis, Torr.* Borders of woods, not common.
P. pratensis, *Linn.* Cultivated for hay and pasture, common.
P. compressa, *Linn.* Dry fields, not very common.
Eragrostis poæoides, *Beauv.*
Var. megastachya, *Gray.* Waste places, gardens, rare.
E. pilosa, *Beauv.* Barren sandy fields, not rare.
E. capillaris, *Nees.* Dry sandy fields, not common.
Festuca tenella, *Willd.* Dry sandy soil, not very rare.

F. ovina, *Gray*. Var. duriuscula, *Gray*. Near the coast, not rare.

F. elatior, *Linn*. Damp meadows, not rare.

F. nutans, *Willd*. Meadows, not common.

Bromus secalinus, *Linn*. (Chess.) Too common in wheat fields. There is a popular idea, still prevailing, that *wheat* will change into *chess;* but this is as unreasonable, as it would be to believe that *rye* could be metamorphosed into oats or any other kind of grass.

B. ciliatus, *Willd*. Shady woods and river banks, not rare.

Uniola gracilis, *Michx*. Borders of woods and thickets, common.

Phragmites communis, *Trinius*. Good-Luck meadows, O., rare.

Lolium perenne, *Linn*. Meadows, not common.

Triticum repens, *Linn*. Along fences, not common.

Elymus Virginicus, *Linn*. Banks of small streams, rare.

E. striatus, *Willd*. Banks of streams, rare.

E. Canadensis, *Linn*. Banks of Shark River, rare.

Aira flexuosa, *Linn*. Dry hill-sides, not common.

A. cæspitosa, *Linn*. Damp places, rare.

Danthonia spicata, *Beauv*. Dry barrens, very common.

D. glumosa. This southern species has been found near Manchester, O., in a single locality, rare.

Arrhenantherum avenaceum, *Beauv*. Meadows, Shark River, M.

Holcus lanatus, *Linn*. (Velvet-grass.) Meadows, not rare.

Hierochloa borealis, *R. & Schultes*. Border of salt marshes, near Squan Village, M., very rare.

Anthoxanthum odoratum, *Linn*. Meadows, common.

Amphicarpum Purshii, *Kunth*. Wet sandy places, near Manchester, O., very rare.

Paspalum setaceum, *Michx*. Dry sandy fields, common.

P. læve, *Michx*. Damp meadows, not common.

Panicum filiforme. Dry sandy soil and road-sides, common.

P. Sanguinale, *Linn*. Waste and cultivated fields, common.

P. anceps, *Michx*. Wet sandy soil, pine barrens, O., common.

P. agrostoides, *Spreng.* Wet meadows, common, M.
P. capillare, *Linn.* Cultivated fields, rich soil, common.
P. virgatum, *Linn.* Dry and moist sandy and gravelly soil, not rare.
P. latifolium, *Linn.* Thickets and river banks, common.
P. clandestinum, *Linn.* Shady places, common.
P. dichotomum, *Linn.* Dry and damp soil, woods and fields, a very variable species everywhere, common.
P. verrucosum, *Muhl.* Sandy swamps, near the coast, rare.
P. Crus-galli, *Linn.* (Barnyard grass.) Rich cultivated fields, var. hispidum, *Gray.* Near salt water, usually of a brown color and with long awns, common.
Setaria verticillata, *Beauv.* Cultivated fields, not common.
S. glauca, *Beauv.* Fields and yards, not common.
S. viridis, *Beauv.* Fields, rare.
Cenchrus tribuloides, *Linn.* Sandy soil, too common.
Andropogon furcatus, *Muhl.* Dry and damp soil, rare.
A. scoparius, *Michx.* Sandy soil and barren plains, common.
A. Virginicus, *Linn.* Sandy soil, not rare.
A. macrourus, *Michx.* Low grounds, common.
Sorghum nutans, *Gray.* Dry soil, common.

SERIES II.

CRYPTOGAMOUS or FLOWERLESS PLANTS.

Class III—ACROGENS.

ORDER CXXXV.—EQUISETACEÆ. (Horsetail Fam.)

Equisetum arvense, *Linn.* Damp places, common.
E. hyemale, *Linn.* (Scouring Rush.) Wet banks, rare.

ORDER CXXXVI.—FILICIS. (Ferns.)

Suborder II.—Polypodineæ. (The true Fern Family.)

Pteris aquilina, *Linn.* (Common Brake.) Pine barrens and woods, common.
Woodwardia angustifolia, *Smith.* Borders of swamps, common.

W. Virginica, *Willd.* Swamps, not so common.
Asplenium binum, *Ait.* Side-hills, rare.
Aspidium Noveboracense, *Willd.* Moist thickets, common.
A. acrostichoides, *Swarts.* Hillsides and shady ravines, not common.
Onoclea sensibilis, *Linn.* Damp or wet places, common.

SUBORDER II.—OSMUNDINEÆ. (FLOWERING FERN FAMILY.)

Schizæa pusilla, *Pursh.* Low grounds, Toms River, and near Kettle-Creek, O., very rare.
Lygodium Palmatum, *Swarts.* Damp springy places, near Shark River, M., very rare.
Osmunda regalis, *Linn.* Var. spectabilis, *Gray.* Swamps, common.
O. cinnamomea, *Linn.* Damp woods, common.

SUBORDER III.—OPHIOGLOSSEÆ. (THE ADDER-TONGUE FAM.)

Botrychium lunarioides, *Swartz.* Shady thickets, rare, M.
Lycopodium alopecoides, *Linn.* Damp fields and swamps, common.
L. dendroideum, *Michx.* Shady woods, rare.
L. Carolinianum, *Linn.* Borders of swamps, common.
L. complanatum, *Linn.* Damp open neglected fields, rare.
Sellaginella apus, *Spreng.* Point Pleasant, O., rare.

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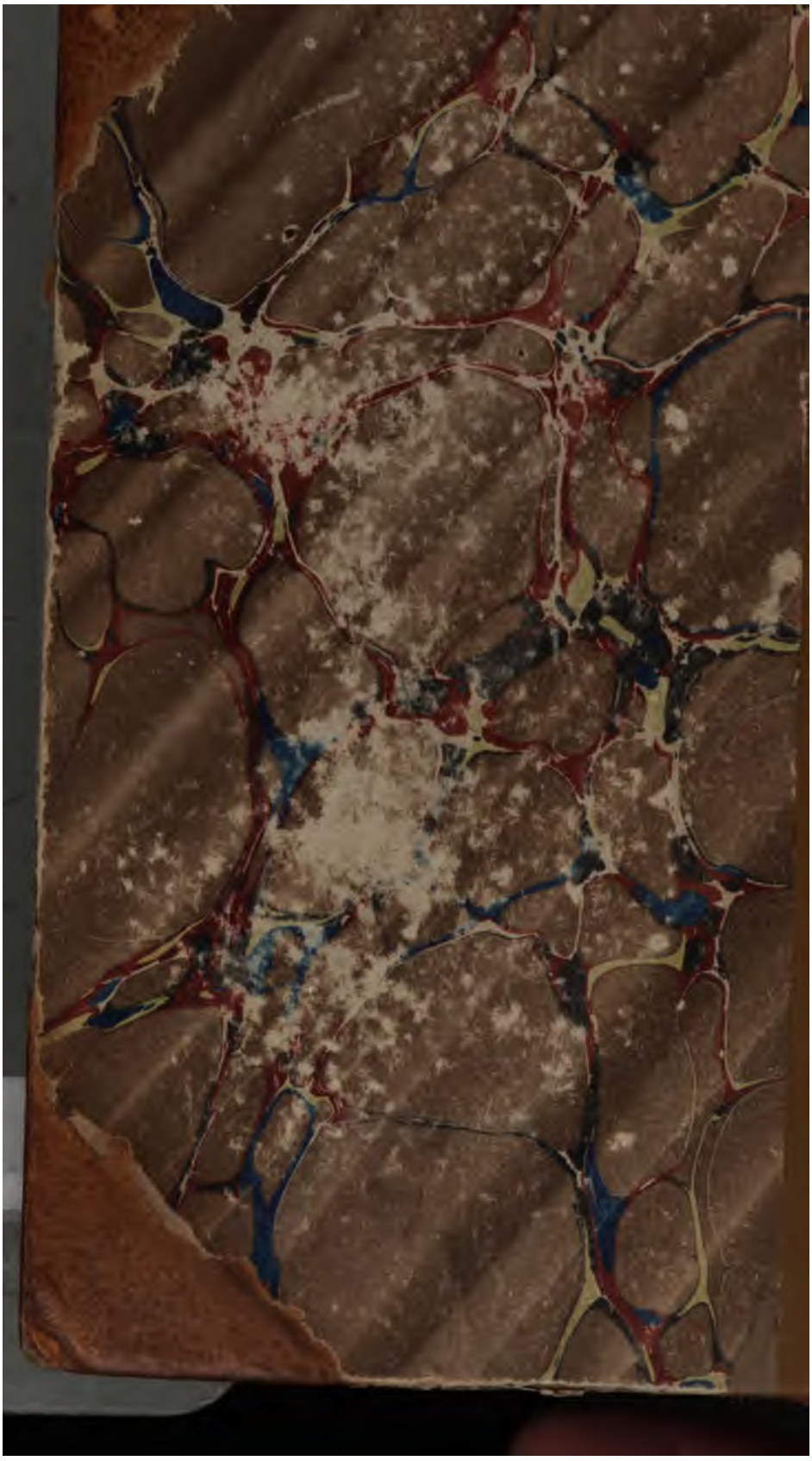
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